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750 miles of coaxial cable for Argentina's new communications network were laid at a depth of almost 4 ft with the aid of trenchers and pay-out trucks

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Argentina's New Long-Line Communications Network

By Friedhelm Leichsenring and Rudolf Krohn

Although some ten times the size of West Germany, Argentina has less than half as many inhabitants, the majority of whom are concentrated in the few economic centers of the country. This and the long distances separating the state capital from the provincial capitals were the principal reasons for the country's earlier communications network having been constructed almost exclusively of open-wire lines. It was operated by private companies, among which was also the "Siemens Platense".

At the beginning of 1952 most of these companies were nationalized. All telephone business was placed in the hands of the Teléfonos del Estado, which is today known as the Empresa Nacional de Telecomunicaciones (ENTel). It was only after this collectivization that nationwide planning became for the first time feasible.

The vigorous economic growth of the country and the rapid increase in telephone traffic made the planning of a practically new, liberally conceived, flexible telephone network an urgent necessity. Statistics recorded over many years covering telephone traffic between Argentinian cities showed the rate of growth in Argentina to increase by between 9 and 12% each year, as compared with about 4% in countries that are better equipped with communications facilities.

As long-term considerations of economy spoke against the expansion of the existing open-wire line network with its large groups of some 200 telephone circuits by the required factor of 10, the establishment of the following network appeared recommendable.

In correspondence with the location of the country's economic centers, the main axis of the network runs from north to south from Santa Fé, through Rosario, to Mar del Plata, with Buenos Aires approximately in the middle (Fig. 1). The more remote cities to the north and west of the main axis are linked up by way of small line-groups formed by stringing additional lines to the pole system and by the use of carrier.

This axis, however, is required to permit the establishment of large groups of telephone circuits with many dropouts. The Argentinian telephone administration early recognized that such a demand could be met only with the aid of the most up-to-date technique using a composite coaxial cable. The coaxial pairs of this cable furnish extremely large numbers of long-distance telephone circuits, while the balanced carrier and v-f circuits in its interstice wires serve to meet short-haul requirements. Since the axis runs for the most part through the pampas, a region that is particularly suitable for cable laying by virtue of its geological structure, and since a large number of dropouts for junction traffic are required along the main route, it was logical to use coaxial cable in preference to broadband radio relay systems.

In planning the new network, the Argentinian administration also made due provision for future direct distance dialing.

Since the carrier technique furnishes channels for a relatively low outlay, the Argentinian administration chose a network of largely radial character with a minimum of switching centers. From and to Buenos Aires, which represents the heart of the network, the main traffic is carried by coaxial channels; for the direct interconnection of small towns, channels must be switched to open-wire lines and junction cables at dropout and terminal points of the coaxial route. Short-haul traffic along the route is assigned to the v-f interstice wires of the cable.

The specifications covering the new long-line network were issued by the Argentinian administration in 1953. Provision was to be made not only for telephone traffic, but also for radio and tv broadcasts, and for telex. This large-scale order was awarded to the Siemens organization in the face of the keenest international competition.

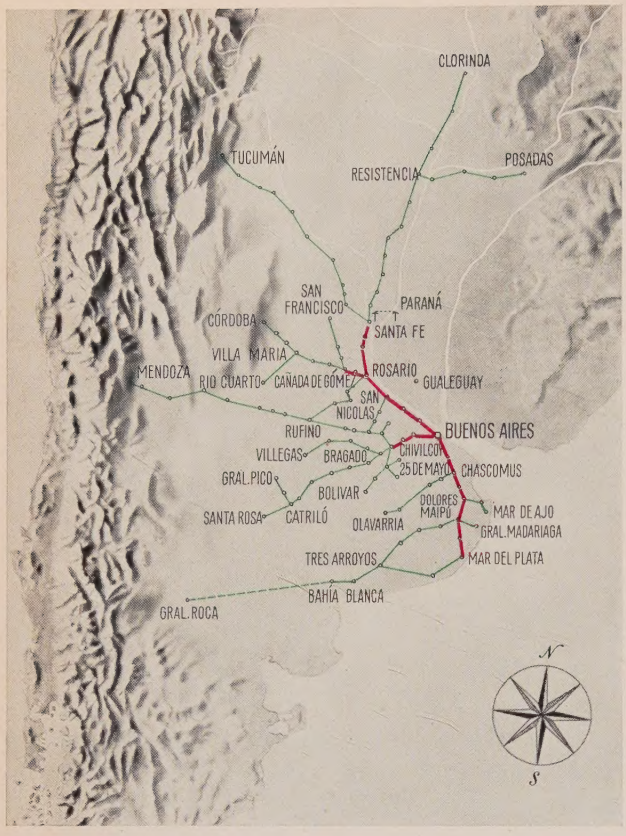


Fig. 1 Network configuration

The heart of the project is represented by three coaxial cable routes of a total length of almost 1200 km (750 miles) and extending from Buenos Aires to Rosario, Santa Fé and Cañada de Gómez in the north, to Chivilcoy in the west, and to Mar del Plata in the south. Many of the cities through which the cable passes are starting points of an open-wire line network some 7000 km (4375 miles) in length, part of which is already installed, while the rest is still in construction by the ENTel. This network takes in even the remotest cities such as General Roca, Mendoza, Tucumán and Posadas (Fig. 1). Carrier equipment is to be widely used in this extensive network. Santa Fé and the city of Paraná on the other side of the Paraná river are interconnected by a radio link operating with 60 telephone channels.

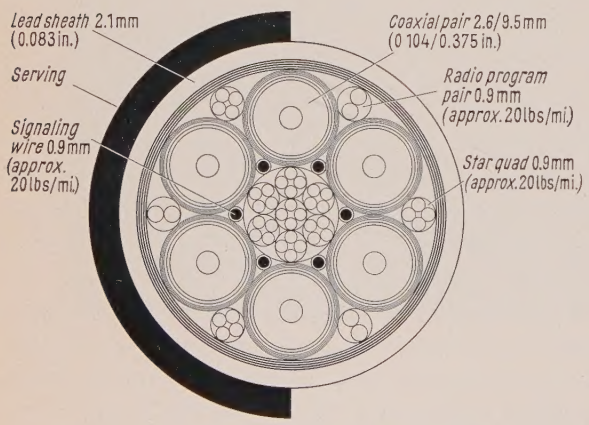

Lead sheath 2.1 mm (0.083 in.)
Serving
Signaling wire 0.9 mm (approx. 20 lbs/mi.)
Coaxial pair 2.6/9.5 mm (0.104/0.375 in.)
Radio program pair 0.9 mm (approx. 20 lbs/mi.)
Star quad 0.9 mm (approx. 20 lbs/mi.)

Fig. 2 Cross section of composite coaxial cable

Cable makeup

Within the cable (Figs. 2, 3) six coaxial pairs 2.6/9.5 mm (0.104/0.375 in.) are arranged around a core of 1 + 6 = 7 paper-insulated star quads with 0.9 mm (approx. 20 lbs/mi.) copper conductors. Arranged alternately in the outer interstices of the six CCI coaxial pairs are one star quad with 0.9 mm (approx. 20 lbs/mi.) copper conductors for telephony and one shielded pair with 0.9 mm (approx. 20 lbs/mi.) copper conductors for tv sound. Six PVC-insulated conductors arranged in the inner interstices of the coaxial pairs serve for connecting the contact pressure gages with the gas-pressure alarm system at attended repeater stations. The available cross section is thus extremely well utilized. The core wrapping is covered by a lead alloy sheath with a thickness of 2.1 mm (0.083 in.).

For several short lines between cities with relatively heavy telephone traffic the cable makeup chosen has over the core already described a layer with 33 paper-insulated star quads with 0.9 mm (approx. 20 lbs/mi.) copper conductors. Both types of cable are available designed for use as:

buried cable with double Hessian tape wrapping,

armored buried cable,

buried cable with special protection against corrosion,

river cable with 2.5 mm (0.098 in.) lead sheath and galvanized flat wire armoring,

bare conduit cable,

corrosion-protected conduit cable with PVC sheath.

The table shows how the cable conductors are assigned.

It is seen that different types of conductors are combined under a lead sheath with an inner diameter of 37 mm (1.46 in.) .750 v, 50 cps threephase current is transmitted over the inner conductors of the coaxial pairs for powering the unattended repeaters. Although these different systems operate in parallel over long distances, appropriate measures taken with respect to both cable and equipment positively exclude the danger of inter-system interference.

Gas-pressure alarm system and cable accessories

The concentration of so many communications circuits in a single cable demands that special attention should be paid to securing high operating reliability. In order to protect the cable as far as possible from external damage, it was buried at a depth of 1.2 m (almost 4 ft). It is also

Conductors	Quantity	Mutual capacitance nanofarads/km	Mutual capacitance nanofarads/mi. (approx.)	Coil inductivity mh	Coil spacing km	Coil spacing ft (approx.)	Repeater span km	Repeater span mi.	Transmitting system	Frequency band kc	Quantity of channels
Coaxial pairs 2.6/9.5mm (0.104/0.375 in.)	6										
of which	2	—		—	—		9	$5^5/_8$	V 960	60 to 4028	960 4-wire v-f circuits
of which	2	—		—	—		9	$5^5/_8$	Tv	308 to 6200	one tv channel in each direction
of which	2*	—		—	—		9	$5^5/_8$	V 960	60 to 4028	960 4-wire v-f circuits
Star quad 0.9 mm Cu (20 lbs/mi.)	10										
of which	4	31.0	49.8	—	—		18	$11^1/_4$	Z 12	6 to 108	96 carrier v-f circuits
of which	3**	31.0	49.8	66	1.83	6004	—		V-f	0.3 to 3.4	6 v-f circuits
of which	3	36.0	57.8	66	1.83	6004	—		V-f	0.3 to 3.4	6 v-f circuits
Shielded r-f pairs 0.9 mm Cu (20 lbs/mi.)	3	37.0	59.4	6.0	0.915	3002	36 or 45	$22^1/_2$ or $28^1/_8$	V-f	0.05 to 15	3 tv sound channels
Signaling wires 0.9 mm Cu (20 lbs/mi.) insulated with PVC	6	—		—	—		—		Signaling circuits for gas-pressure monitoring	d-c	3 signaling circuits
Additional star quads for type II cable 0.9 mm Cu (20 lbs/mi.)	33	36.0	57.8	66	1.83	6004	—		V-f	0.3 to 3.4	66 v-f circuits

* Standby
** After being deloaded, these three star quads can be assigned six Z 12 systems so as to yield 72 carrier telephone circuits

Characteristics and assignment of the conductors of the composite coaxial cable

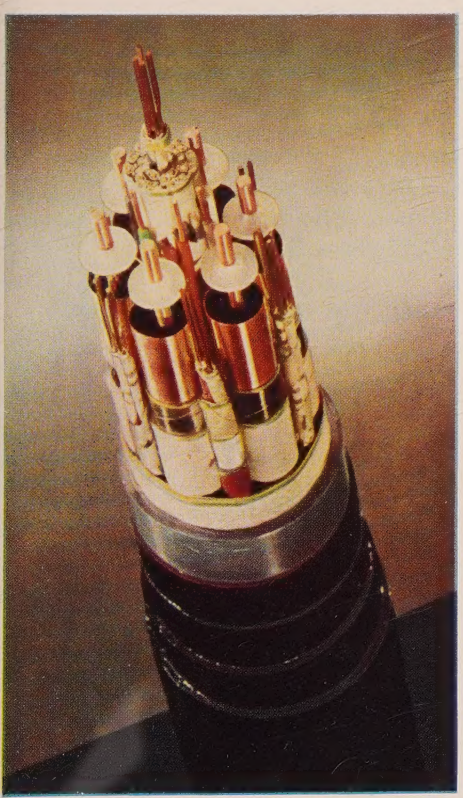


Fig. 3
Staggered sample of composite coaxial cable

monitored by a gas-pressure alarm system which transmits an alarm whenever even the smallest leak develops in the cable sheath.

The project of constructing a gas-tight cable system gave rise to a number of problems in connection with the design of the cable accessories. Sheet brass was here chosen instead of the conventional lead. The gas-tight termination of the conductors was realized with the aid of lead-throughs made of glass. It was naturally also necessary for the loading coils and building-out networks to be accommodated gas-tight in suitable cylinders in the bottom part of the coil sleeves. The loading coils have SIFERRIT* shell cores and are outstanding for their extremely small size and excellent electrical characteristics.

Laying and installation of cable

The cable route and location of the repeaters were chosen in consultation with representatives of the customer and the responsible authorities. For the most part the route runs alongside overland highways, which are secure from floods. The terrain and the geological structure of the subsoil permitted the use of ditchers (see colored illustration opposite page 1) in excavating the 1.2 m

* Trade-mark

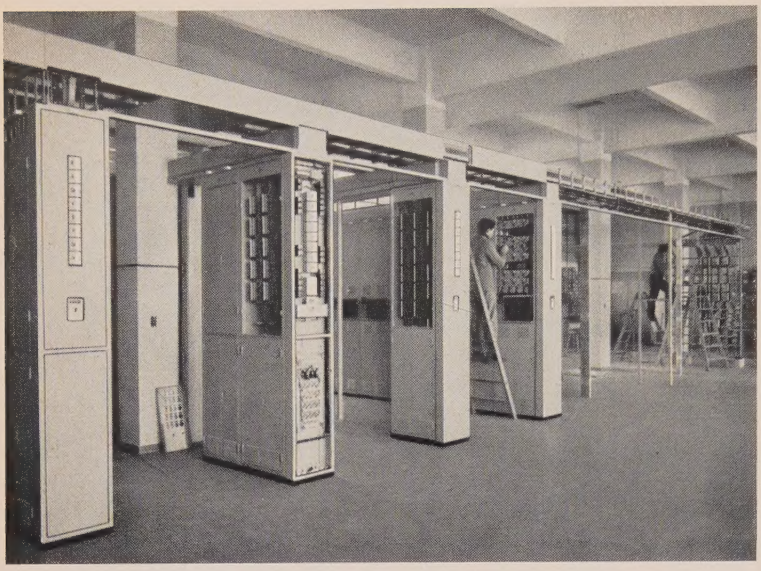


Fig. 4 Installation work at Rosario carrier office

(almost 4 ft) deep trench. Trenching work was in this way greatly simplified. The cable was payed out carefully from trucks directly into the trench by a mere handful of unskilled workers. The trench was then filled in by mechanical means.

The installation of the cable and the electrical lineup measurements presented a great many organizational problems on account of the vastness of the Argentinian plains. Installation personnel had to be accommodated in caravans with satisfactory sanitary facilities. The work was rendered particularly difficult by frequent high relative humidity, tropical rainfall and heat in summer and by low temperatures with high relative humidity in winter. Floods sometimes led to interruptions in work lasting several months. Despite all these difficulties, rapid progress was made in laying and installation with the effective support of the Argentinian administration.

Telephony and telegraphy

The many different problems engendered primarily by the widely differing groups of telephone circuits in the various sections of the network were solved by recourse to a small number of carrier systems. Their well-coordinated frequency allocations permit simple carrier switching (from 12-channel to 60-channel groups) between systems. The following carrier equipment is used:

Z 12 and V 960 coaxial system (12 and 960 telephone circuits)	for the cable route
Z 3 F and Z 12 F (3 and 12 telephones circuits)	for the open-wire lines
FM 60/2000 (60 telephone circuits)	for the radio link

All long-line carrier systems feature out-of-band signalling, thus readily permitting the introduction of direct distance dialing as an ultimate goal.

Fig. 5 One of more than 100 repeater buildings in the pampas

24 telegraph channels can be accommodated in a single telephone channel (300 to 3400 cps). The 24-channel v-f carrier telegraph systems required for this purpose have been assigned to practically all coaxial and open-wire line routes, and a total of 1080 channels are available.

Radio and tv program transmission

Carrier radio program channels leading, along with the carrier telephone channels, to all parts of the country, have been established for the distribution of radio programs. Distribution panels installed at network junctions permit such programs to be connected through on a carrier basis and suitably distributed.

Tv picture signals are transmitted over two coaxial pairs of the cable – one serving for each direction – with repeaters spaced the same distance apart (9 km or $5\,^{5}/_{8}$ miles) as with the V 960 carrier system. Tv sound is transmitted over the high-

quality v-f radio program circuits of the interstice pairs.

Repeater stations

The lengths of the repeater spans of the various transmission systems are coordinated as multiples of each other. The span is 9 km ($5^5/_8$ miles) for V 960 and tv, 18 km ($11^1/_4$ miles) for Z 12 and 36 km ($22^1/_2$ miles) (also 45 km or $28^1/_8$ miles) for radio program transmission.

The majority of repeater stations are unattended. From eight to ten unattended repeater stations – depending on the length of the route and local conditions – are interposed between two attended repeater stations.

Unattended repeater stations are remote-powered from the attended stations over the inner conductors of the coaxial pairs of the cable. Fig. 5 shows an unattended station along the route from Buenos Aires to Rosario. The more than 100 repeater buildings of this type were erected by the ENTel, using for the most part prefabricated sections.

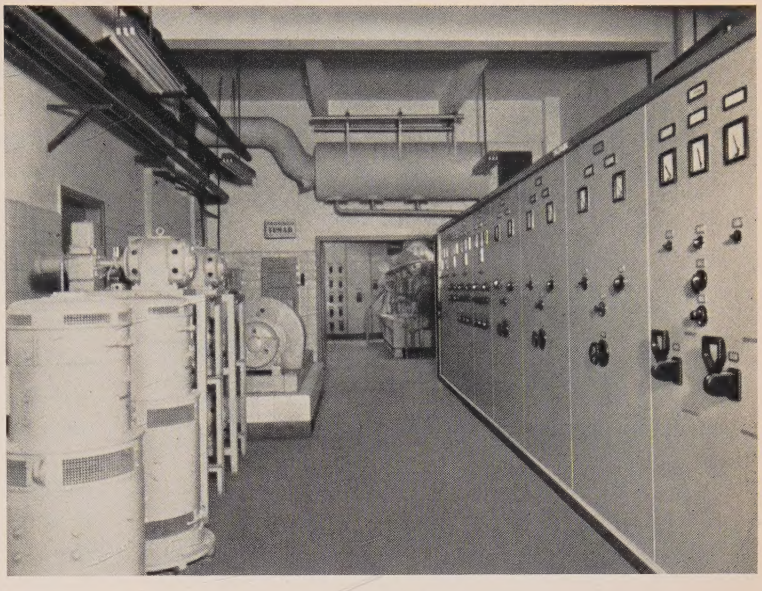


Fig. 6 Inside the power supply section of Buenos Aires office

All remote-powering stations operate with standby power supply plants which insure that there will be no interruption in communication in the event of failures of local power supply networks (Fig. 6).

An idea of the amount of work involved may be obtained from the following statistics.

Some 2500 rack units had to be supplied and installed for the initial stage of network development; almost 1200 km (750 miles) of cable had to be laid and its electrical characteristics measured; some 120 repeater stations had to be built, and a total of about 290 had to be equipped.

Some of the equipment was manufactured in Argentina, whose factories, which include a tube factory, will be in a position to supply a considerable quantity of the equipment required for the expansion of the network.

Argentina's new long-line communications network as planned by the ENTel and constructed by the Siemens organization offers liberal scope for further expansion without any large-scale building work or the installation of new cable being necessary.

Comparative Evaluation of Power Sources for Arc Welding

BY ERNST HOLTEY

In addition to welding sets and welding transformers, welding rectifiers have found widespread application in the course of the last few years. The availability of two power sources of quite different nature for d.c. arc welding has again directed interest to making a comparison between the different power sources. In addition to the numerically evaluable characteristics (open-circuit consumption, efficiency, power factor) in such investigations, other factors, such as welding property, applicability, operational performance etc. must not be overlooked. Generally, these factors do not receive due consideration although they play an important part in evaluating the power sources from the economical point of view.

In d.c. welding it is the general practice to use rotary welding sets. Similar to the approaches made in other fields of electrical engineering, efforts have been made for some years to find a power source for arc welding, which is free from rotating parts, i.e. a static device. The expected reduction in the maintenance costs in addition to power savings (as a result of lower open-circuit losses and a higher efficiency) calls for a static device.

The welding set is a motor generator and therefore a generator of current. The welding transformer and the welding rectifier, however, draw the electrical energy required for welding directly from the mains; the system

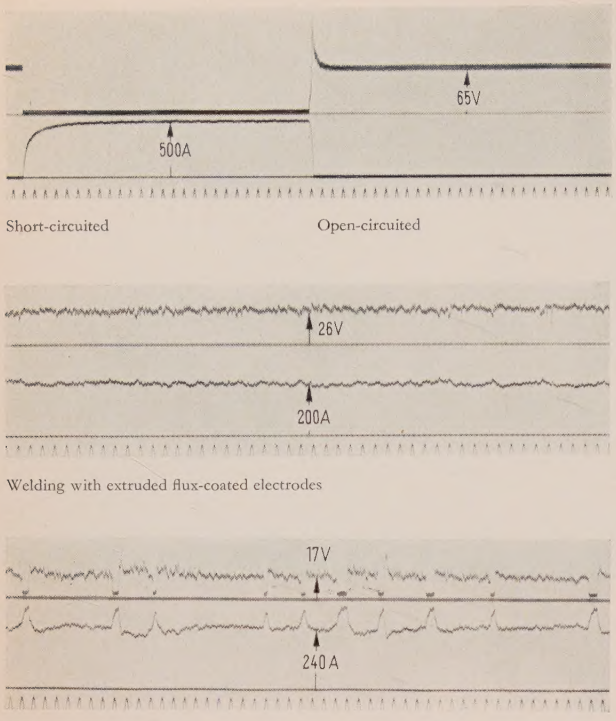
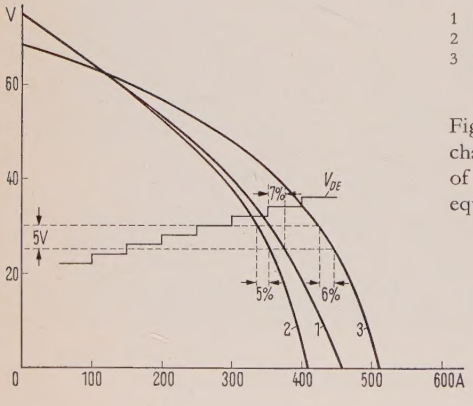


Fig. 1 Oscillograms of welding sets

voltage is merely stepped down or rectified as the case may be. With present-day welding generators a distinction is made between differential series-wound, cross-field and diverter-pole welding generators. Of these three types the diverter-pole generator has particularly advantageous features. The open-circuit voltage remains constant at all welding currents which can be steplessly adjusted in the respective range and this is of particular advantage for striking the arc. The special arrangement of the main and diverter poles ensures inertia-free operation. Single-phase welding transformers are generally used as power source for a.c. welding. With welding transformers a drooping static characteristic is obtained by connecting an additional reactor into the welding current circuit or by establishing a special leakage path for the magnetic flux by means of suitable design measures. Of the possible control methods the stepless current control, introduced during the last few years, by means of a d.c. biased reactor (transductor) has proved very satisfactory. A constant open-circuit voltage is maintained over the range selected.



1 Welding set
2 Welding rectifier
3 Welding transformer

Fig. 2 Static characteristics of welding equipments

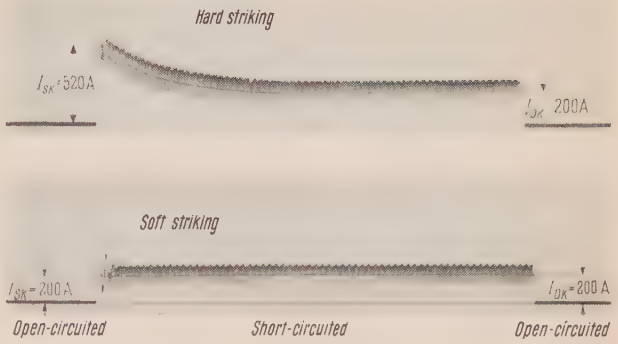
As with the welding transformer, the welding rectifier draws the electrical energy from the mains system via a coupling transformer which, in contrast to the welding transformer, is of the three-phase type, and likewise, a reactor is used for adjusting the current. The three-phase current passing through the transformer and the reactor is converted into d.c. current in the rectifier set which is generally arranged in three-phase bridge connection. The majority of present-day welding rectifiers have selenium plates. For outdoor applications at elevated atmospheric humidity the selenium rectifiers are best protected from the ingress of air by immersing them in oil. The silicon rectifier recently introduced is a further advance since the encapsulated silicon cells are insensitive to atmospheric humidity and contaminated air.

The static characteristic which is often used in the evaluation of the welding generators shows the relationship between current and voltage under steady-state conditions. Starting with a definitive open-circuit voltage, which must not exceed 100 V d. c. or 70 V a. c. according to the VDE regulations in force, the voltage drops in the short-circuit point to zero with rising current. The welding generators, transformers and rectifiers have static characteristics of the same basic shape. Fig. 2 shows the static characteristics of welding sets, rectifiers and transformers of medium capacity. Depending on the degree of drooping of the static characteristic of the welding power source, the current changes to a greater or lesser degree for a constant rate of change in the voltage which is assumed to be 5 V. From the welding point of view it is desirable that the unavoidable changes in the length of the arc do not result in too heavy current fluctuations. The static characteristic should therefore not be too flat. On the other hand, an experienced welder prefers a moderately steep characteristic since he can then tell much better from the moon-shaped arc, i.e. the root of the arc at the workpiece, whether he is operating with the correct current or not. In addition, he is compelled to keep the length of the arc as short as possible. The characteristic curves of the welding set, transformer and rectifier result in static current fluctuations of practically the same magnitude. These current fluctuations occur, however, only after a certain time. They can therefore be used only conditionally or not at all for evaluating the welding properties of the various power sources. The static characteristic is used primarily for a comparison of the welding currents obtaining at the corresponding working voltage (see VDE 0540 and 0541).

The major considerations in the comparative evaluation of the welding generators concern the welding properties.

The decisive factors in this respect are not only the steady-state variations of current and voltage, but also the characteristics of the transient phenomena which can be recorded oscillographically and which are known as the dynamic characteristic. Although the significance of the dynamic characteristic has been reduced as a result of the improved arc stability and the material transfer in the arc in the form of fine droplets when using conventional, coated electrodes, equipment with a good dynamic characteristic is always superior. For difficult welding jobs, e.g. in a vertical position or for operating with base-forming electrodes with a transfer of six to eight droplets per second, a satisfactory dynamic characteristic is essential in order to prevent interruption of the arc. Differences in the arc stability also affect the labour costs since they influence the duty cycle. Such differences are of greater importance than, for example, differences in the efficiency which can only affect the power costs which are in any case relatively lower [1].

The importance of the impulse short-circuit current on striking the arc and of the impulse open-circuit voltage after breaking the short circuit has been generally recognized. An inertia-free welding generator (Fig. 1) considerably attenuates the impulse short-circuit current which decays rapidly to the steady-state value. It also provides the desired high transient surge voltage which builds up in less than half a cycle or $^1/_{100}$ of a second (at 50 c/s) and which does not drop below the steady-state value during the transient period. This satisfactory dynamic performance makes for ease in striking the arc and for stability of the arc [2]. For the welding rectifier which, contrary to the welding motor generator is connected to the mains system via a transformer with a definite step-down ratio, the static and dynamic open-circuit voltages are practically the same in the case of a mains system with a stable voltage. The welding properties of the welding rectifier should therefore be evaluated on the basis of the magnitude of the impulse short-circuit current occurring on striking the arc, which is mainly determined by the damping effect of the apparatus (Fig. 3). A high impulse short-circuit which decays slowly means "hard" striking. If, however, the impulse short-circuit current has a peak which is greatly attenuated during the transient period and which decays rapidly with an energy content of practically nil, "soft" striking of the arc with a minimum of electrode splatter and a stable arc will be ensured. With regard to the welding properties, this welding rectifier is of almost the same standing as the welding generator set. Fig. 4 shows oscillograms of bare-electrode welds, namely (*a*) with the welding generator and (*b*) with the welding rectifier. To ensure similar conditions, welding was carried out with an automatic welder. The electrode rod had a diameter of 5 mm (0.2 in.). The time variation of the current and voltage was approximately the same in both cases. On an average, the impulse short-circuit current is of about the same magnitude for both the rectifier and the welding set, and the relationship to the welding current is also practically the same. The welding set only provides more pronounced damping of the impulse short-circuit current.



I_{Sk} Impulse short-circ. current I_{Dk} Sustained short-circ. current

Fig. 3 Oscillograms of the welding current from welding rectifiers

The considerations concerning the welding properties of the welding sets and welding rectifiers also apply in a similar way for the welding transformer. In the case of the welding transformer the voltage is inductively coupled to the mains system as in the case of the welding rectifier, so that the open-circuit surge voltage is practically equal to the static open-circuit voltage with a stable system. The magnitude of the impulse short-circuit current for the welding transformer depends, as for the welding rectifier, on the effectiveness of the reactor equipment. It also depends on the instantaneous value of the current at which the arc is re-struck. In evaluating the welding properties of the welding transformer an additional factor to be considered is that the current pulsates continuously between a positive and a negative value, i. e., it passes through zero twice within a cycle or one hundred times every second. This means that the current would be interrupted and the arc extinguished if this

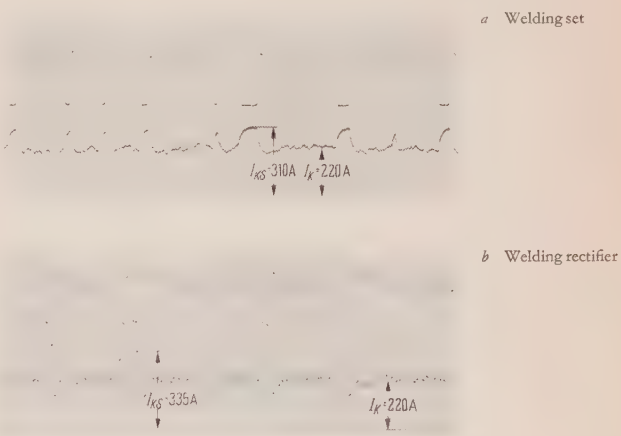


Fig. 4 Oscillograms of welds with bare electrode rod

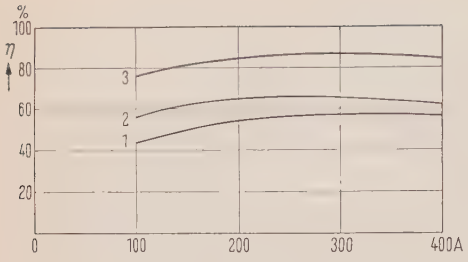


Fig. 5
Efficiencies of welding equipments

1 Welding set
2 Welding rectifier
3 Welding transformer

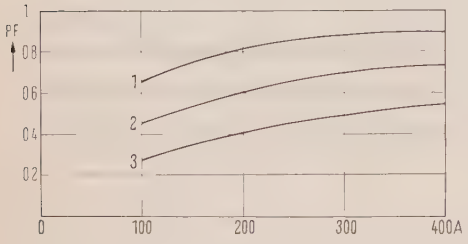


Fig. 6
Power factor of welding equipments

	Welding set	Rectifier	Transformer
Mains supply	3-ph	3-ph	2-ph
Load on system	balanced	balanced	unbalanced
Surge load on system	damped	undamped	undamped
Effect of mains voltage fluctuations	small	proportional	proportional
Failure of one mains phase (single-phasing)	Danger for the machine	No danger, reduction in power	No danger, equipment is no longer operative
Open-circuit losses referred to continuous primary power, (approx.)	18%	8%	5 %

Table 1 Comparative evaluation of welding equipments with respect to the mains supply

	Welding set	Rectifier	Transformer
Electrodes			
bare	yes	yes	no
covered	yes	yes	yes
alloyed	yes	yes	conditionally
Polarity reversal by	switch	plug	–
Magnetic blow effect	moderate	moderate	none
Noise	loud	low	none
Maintenance	moderate	slight	very slight

Table 2 Comparative evaluation of welding equipment in respect of its application

were not prevented by the ionising constituents of the electrode coating. Tests have shown that the welding properties of a welding transformer are substantially influenced by the angle at which the current passes through zero. A flat approach means a prolonged zero current period which may prevent the electrodes from re-striking the arc [3]. In the comparative evaluation the efficiency and the power factor play a part which has been frequently discussed. Fig. 5 shows the efficiency of a welding set, a welding rectifier and a welding transformer of about the same rating as a function of the welding current. At 200 A, for example, the efficiencies of the welding set, rectifier and transformer are 55%, 65% and 85%, respectively. Compared with its efficiency the welding transformer has the lowest power factor (Fig. 6). At 200 A the rectifier, with a power factor of 0.6, takes up the approximate mid-position between the welding set with 0.85 p.f. and the welding transformer with 0.4 p.f. In many cases, therefore, the welding transformers are equipped with capacitors to improve the power factor.

Table 1 is a compilation of data for comparative evaluation with respect to the mains power supply. Welding set and rectifier are connected three-phase, thus distributing the load uniformly over the three phases; transformers, however, are connected to the system via two conductors only, thus causing an unbalance of the load. The reaction on the mains system is, in the case of direct coupling, i.e. transformer and rectifier, considerably greater than for the welding set which can compensate load surges by means of the energy stored in the rotating masses. Likewise, as a result of the direct coupling of the transformer and rectifier to the mains system, any fluctuations in the mains voltage are proportionately reflected in the secondary voltage. This effect is not experienced with the welding set since its speed depends on the frequency and not on the voltage. The influence via the field excitation is rather limited. The failure of one phase conductor causes the welding set to operate on two phases only and this may ultimately lead to the burning out of the motor winding. In the case of the rectifier, the failure of one conductor results in a substantial reduction of the output. A welding transformer is no longer ready for operation in the event of failure of one of the phase conductors. A comparison of the open-circuit losses, referred to the continuous primary load of the welding set, rectifier and transformer, results in differences of 18, 8 and 5% of the primary continuous load. Table 2 gives a comparison from the point of view of application. The welding set and the rectifier can be operated with bare, covered and alloyed electrodes. The transformer is not suitable for operation with bare electrodes, and with alloyed electrodes only under certain conditions. A polarity reversal of the electrode from the negative to the positive pole (e.g. with base-forming Kb-electrodes) can be effected by means of a small excitation switch in the case of the welding set, while with the

rectifier the welding cables must be interchanged either by re-connecting or re-plugging. The magnetic blow effects in making edge and fillet welds with a welding set or welding rectifier are moderate with either power source and are almost equal from the practical point of view [1]; they are very low with the transformer. The noise is highest with the rotary welding set. With the rectifier only the noise produced by the fan is present, while with the transformer the noise due to the reversal of the magnetic flux in the core is hardly noticeable. The transformer has the lowest maintenance requirements.

It would seem that the welding transformer is the arc-welding equipment of the future, owing to its low capital and running costs. This may be true in the case of secondary welding jobs. D.C. welders are, however, indispensable as universal appliances, especially with regard to the electrodes available and the degree of quality attainable. In addition to the electrical and physical properties, the suitability and operational performance of the welding equipment is of decisive importance in practice. In many installations particular importance has to be attributed to the reliability in operation and the safety afforded against accidents – factors which outweigh all other considerations. Also important is the question of costs, e.g. in boiler construction, in shipbuilding and at remote erection sites. These factors have to be taken into account when making a comparative evaluation, particularly in view of the fact that the current consumption is only a relatively small percentage, namely 10 to 15%, and that the amortisation also amounts to only about 10% of the costs of the finished product or welding seam, the major portion being made up of the labour costs.

The selection of the most suitable welding power source and the evaluation for the respective application must, of course, be left to the discretion of the user since the application can vary within wide limits and since no equipment offers merely advantages. However, knowledge of the specific properties of the welding equipment and its operational performance will be a great asset in the selection of the proper power source.

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The Junction Interlocking at Frankfort's Central Railroad Station

By Fritz Ackermann

The new railroad signaling technique developed by the Siemens Telegraph and Signaling Division in Braunschweig not only insures the safety of railroad traffic at stations and along the route, but also secures optimum utilization of the expensive trackage. It further improves the economy of railroad operation, which is one of the prime objectives of modern signaling technique.

The principal item of equipment used in the new signaling technique is the pushbutton interlocking which serves for safeguarding and expediting the movements of trains at railroad stations. Other important items are used for CTC, train number indication, automatic route setting, automatic route blocking, and there is special equipment for shuntyards, level crossings and automatic train control.

A well-coordinated system composed of a pushbutton interlocking, automatic route blocks, CTC and train number indicator equipment permits the automatization and concentration of railroad operation to be extended in the interest of economy to large areas beyond the home station to form what are termed route and junction interlockings.

Route interlockings permit centralized train control along extended railroad lines with their intermediate interlockings.

Junction interlockings can be used to control large junction stations, inclusive of the smaller stations located in

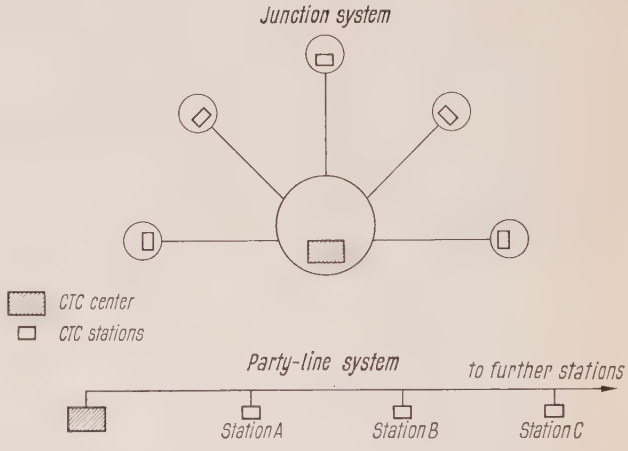


Fig. 1 Schematic representation of typical CTC systems

Fig. 2 The interlocking building: the control room is on the top floor while the floors below accommodate the relay frames for the CTC and telephone equipment and the power supply

the same area, as also the route sections in between (Fig. 1).

Such interlockings were already successfully introduced for private railways in Central Germany in 1937. After the war the experience gained in their operation was drawn upon in designing new junction and route interlockings. As early as in 1951 and 1952 large junction and route interlockings were placed in commission in the Wiesbaden area and along the Bebra – Cornberg and Nuremberg – Regensburg routes in Germany, and at the same time along a 56-mile line in Portuguese East Africa.

In view of the favorable results obtained with this equipment, the West German railroad authorities decided on the construction of a large-scale installation with junction interlocking for the Frankfort area (Fig. 2). Owing to the increasing number of trains that arrive at and depart from Frankfort central station daily (780 trains in 1937, 700 in 1949, 1,250 in 1956), new and faster methods of coping with this growing traffic had to be found.

Planning

In planning the new traffic control system, the West German railroad authorities decided to combine 9 interlockings in various parts of the station area into a central interlocking, to replace the interlockings of outlying stations by pushbutton interlockings, and to adapt them to CTC operation from the junction interlocking. In addition, the route sections between outlying stations and the central station were guarded with automatic route blocks and automatic block signals in order to permit a tighter train schedule.

Owing to the concentration of tracks at the central station and the radial configuration of 9 main routes, the central station is surrounded by a close-knit network of connecting tracks covering a radius of about 7 miles. In both layout and operation, Frankfort is one of the most complex junctions in all Europe.

The present CTC area encompasses 7 interlockings (Fig. 3) that no longer have to be attended. 3 further interlockings have to be operated to order and are therefore attended. Personnel assigned to these interlockings themselves control the movement of trains within the station area, but require the permission of the CTC operator at the central interlocking before giving departure signals. The green dots at interlockings mark the beginning of the train number indicator circuits. The numbers of inbound trains are keyed at these points. The dotted red line with the red dashed stations indicates that the CTC system in its ultimate construction stage will comprise 22 interlockings.

The following units are CTC controlled from the junction interlocking (see Table 1):

1. at Frankfort central station
   430 switches
   470 main and shunting signals
   400 track circuits
2. at 7 outlying stations
   100 switches
   140 signals
   130 track circuits.

The CTC system used has a total capacity of 1,100 control signals and 2,400 return indications.

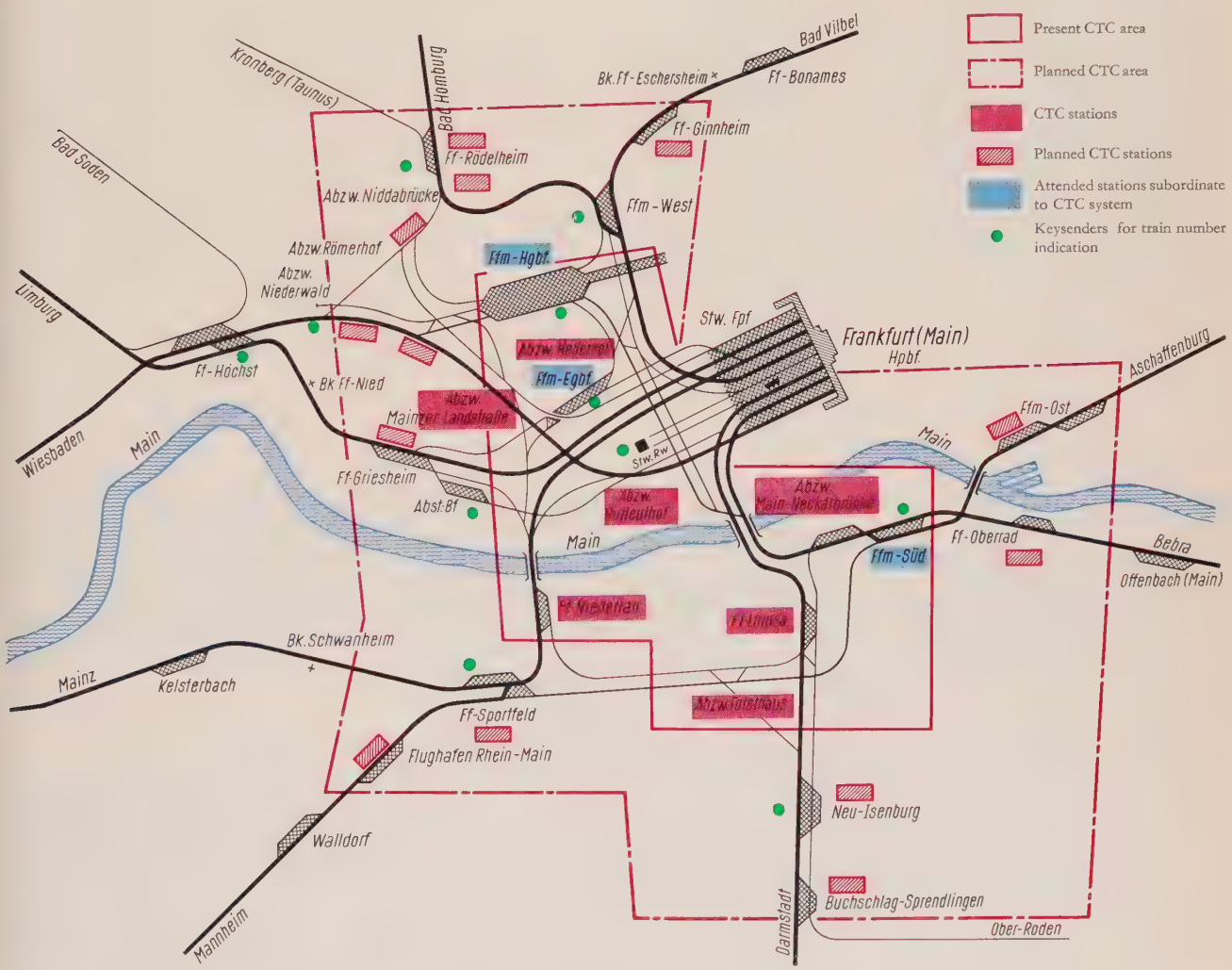
Between outlying stations and the junction interlocking, 37 automatic block signals are installed along a track 46 miles in length.

Traffic control teams

If one considers a railroad station through the eyes of a normal traveler, one thinks in general only of the arrival

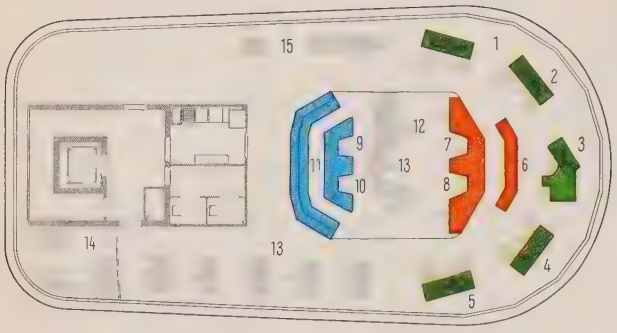
	Frankfort central station	Outlying CTC interlockings
Switches	430	100
Shunting signals	312	5
Departure signals with shunting signal	27	10
Home signals	8	46
Advance signals	27	79
Train protecting signals	96	– –
(Total number of signals)	470	140
Track circuits	400	130
Optical units for train number indication	510	130
Automatic block signals	37	

Table 1 Signaling equipment in CTC area of Frankfort central station



Abst.-Bf. Stapling yard
Abzw. Branch-off station
Bk. Block
Egbf. Express freight yard
Ff Frankfort
Ffm Frankfort-on-Main
Hgbf. Central freight yard
Hpbf. Central station
Stw. Fpf. Interlocking of Frankfort central station dispatcher
Stw. Rw Shunting interlocking of servicing shops

Fig. 3 CTC area of Frankfort central station



1 to 5 Track-diagram control desks at which the switches and light signals of the central station can be operated by pushbutton
6 Display panel of central station on which the station dispatchers are able to observe the luminous numbers of trains approaching and leaving the central station. From their
7 and 8 control console they issue orders to the switchman seated in front of them for setting up the routes they have selected
9 and 10 Control panels of CTC operators, who follow the progress of trains within the CTC area by observing the route track-diagram board 11
12 Station platform public address system
13 Station control post
14 Teleprinter station and pneumatic tube conveyor
15 Control panels for electric train operation and station illumination

Fig. 4 Layout plan of control room

Fig. 5 Switchmens' control desks in control room

and departure of trains on schedule, for shunting operations take place, as it were, behind the scenes. It should be realized, however, that shunting operations, representing a multiple of all other movements, are a factor on which the smooth flow of traffic within a station vitally depends.

In Frankfort, 4,500 shunting operations have to be performed every 24 hours – during rush hours the rate is about 250 an hour – in addition to 1,250 train movements. To this end up to 1,430 shunting routes and 420 normal train routes can be set up.

In order to secure the smooth excution of this vast quantity of movements according to schedule, cooperation is necessary between three work teams that are responsible for the following duties:

Switchmen for control of shunting operations;
Station dispatchers for control of traffic within the central station

Fig. 6 Control room; the two station dispatchers are in the foreground, while seen in the background are several switchmens' control desks

CTC operators for control of traffic in outer station area and moving along approach routes.

All three teams are accommodated in a single room and their actions are always coordinated. Fig. 4 shows the layout of the equipment for the three teams within the control room.

Switchmen

The switchman must be well familiar with operating conditions at the station and must be capable of handling situations with foresight. He is in charge of shunting operations and sets up shunting routes according to his own judgment. Shunters advise the switchmen of pending shunting operations by radio. The shunting operations that have to be performed are the marshalling and separation of coaches and freight cars, the picking up and setting out of mail cars, the picking up and transfer of direct coaches, and the movement of locomotives to and from the servicing shops. The switchman is also required to set up routes in response to instructions received from the station dispatcher.

As a switchman is not physically capable of handling more than a certain number of simultaneous movements, the overall trackage was divided into 5 control areas, with each area assigned a control desk $6\,^1/_2$ ft in length and $2\,^1/_4$ ft in width (Fig. 5).

Station dispatchers

Two station dispatchers – one for the north and one for the south section – control all train movements from their control consoles. They observe the movements of trains on a special display panel on which the train numbers appear, and press buttons to signal switchmen to set up required routes (Fig. 6). The track sections representing such routes on the control desk of the switchman (Fig. 5) thereupon begin to flash as a signal for him to set them up.

CTC operators

Important factors in securing the efficient control of traffic within the station area are a knowledge of the traffic situation and the control of traffic at outlying interlockings and along approach routes.

Two CTC operators – one for the south and one for the north section of the outer station area – control at a control panel the movements of trains indicated on a route interlocking and train indicator board 23 ft in length and 4 ft in height. This board contains a schematic representation of the tracks of all routes and interlockings within a radius of 7 miles. Of the station itself, the board contains in its middle section a representation of only the 24 station tracks; this is followed on the left by the northern and on the right by the southern section of the network (Fig. 7). In the interest of clarity, the various routes on the route interlocking board are marked in different colors. With the aid of the track diagram board the CTC operators are able to observe and control the movement of all trains within a radius of about 7 miles.

This demands the use of train number indicators. When an inbound train reaches the signaling circuit, the dispatcher at the interlocking located at the border of the control area keys its number on a 10-digit keyboard. The keyed number is transmitted in coded form to the central

Fig. 7 The desks of the CTC operators; seen in the background is the route interlocking and display board, which is 23 ft in length

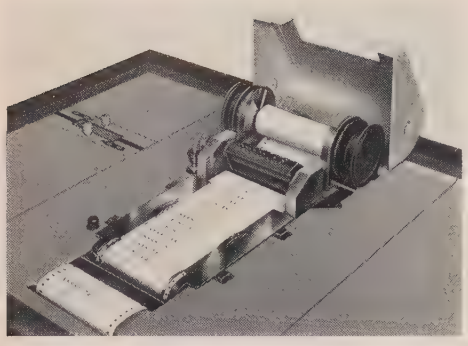


Fig. 8 Train time printer

interlocking, where it is displayed on the route interlocking board. Here it appears on the first indicator unit and is automatically advanced by the train from the approach route, past the interlockings and automatic block routes, to the station track[1].

The number of the train appears not only on the route interlocking board, but also on the display panel of the station dispatchers and on the control desk of the switchman so as to permit recognition of the situation. The train numbers of departing trains are keyed by the switchmen for their respective areas. The numbers appear on the display panel of the station dispatchers and then advance on the route interlocking and display board in congruence with actual train movement towards the outlying stations. Numbers are at the same time displayed on the panel of an announcer, who announces the arrival and departure of trains over a loudspeaker.

The arrival and departure of trains is also automatically registered by a printer, which records the train number, traveling direction, track and time data under the control of the train number indicator system. This printer supersedes the arrival-and-departure ledger which was previously kept by hand (Fig. 8).

Automatic route setting

The display of train movements and train number indication furnish the CTC operators with full and accurate data enabling them to make their decisions. To relieve them of having to set up routes at outlying stations according to a fixed time schedule, widespread use is here made for the first time of automatic route setting. This is of major importance during times of heavy traffic carrying, say, commuters.

When the automatic route setting system is switched on, trains set up their own routes on approaching a certain point within the area of the respective interlocking. This point is so located that the engine driver is already able to determine from an advance signal the aspect to which the main signal is set.

For this purpose a route code is keyed along with each train number. This code is scanned at the train number indicator unit of the display panel where automatic route setting is to begin and is transmitted over the CTC system to the outlying interlocking. Here, a control relay is excited and either directly sets up the desired route or, if this is prevented by another route having been set up, stores the control signal. If several control signals come to be stored as a result of the simultaneous approach of several trains, a finderswitch selects, regardless of the sequence of storage, whichever routes it is momentarily possible to set up. This arrangement secures optimum flexibility in the movement of trains. By actuating a button, however, the CTC operator can stop the storage in order to set up a route on a priority basis for, say, a delayed express train. He can also bring a train to a halt in front of a signal if its passage would disturb the flow of traffic.

These possibilities of intervention keep traffic on the move without the automatic route setting system having to be switched off.

Power supply

The relay and switching cabinets are installed on 3 floors of the interlocking building. On the ground floor are the Diesel generating set for the emergency power supply. The battery, transformers, converter and control panels are in the basement.

Three power sources are available:

1. City power supply network
2. Battery and d-c/a-c (threephase) converter
3. Diesel generating set.

The power demand is approx. 100 kva.

The entire plant is normally powered from the city power supply network. In the event of a power outage, the battery-fed d-c threephase a-c converter takes over and the Diesel generating set automatically starts up. As soon as the latter is ready for operation, it takes over until the city power supply returns.

As all changeover operations take place without any interruption in the supply of power, there is no disturbance to railroad traffic.

Construction and economic efficiency of CTC system

Owing to the smooth collaboration between the railroad authorities and Siemens & Halske, the large CTC system in Frankfort was completed in a relatively short time.

On completion of the planning work, an order was awarded for the supply and installation of the overall traffic control equipment, including the CTC and train number indicator systems.

The first outlying interlocking was placed in commission two years later and the last one year after that. The complete central interlocking, including CTC and train number indicator systems, was placed in service in stages over a period of 14 days. It should be recorded in this con-

1 Franitza, P.: Die Zugnummernmeldung in der Zentralstellwerkanlage Frankfurt (Main) Hbf. Siemens-Zeitschrift **33** (1959) pp. 405 to 408

nection that the deadlines for placing the system in service were already fixed when the order was awarded and were tied up with the electrification program. Another difficulty that had to be taken into account was the expansion of the system at the request of the railroad authorities during the installation period by the incorporation of automatic route setting and other features.

The overall system has come up to expectations in all respects and is operating faultlessly.

Interlocking personnel at the central station have been cut from 105 to 43 persons, representing a reduction of 59%, and in the CTC area from 42 to 8 persons, representing a reduction of 81%. In addition to these considerable cutbacks in personnel, operating costs have also been sliced effectively through the elimination of traffic congestion, the better utilization of tracks, the faster handling of trains, and the considerable reduction of shunting accidents, which have dropped by 98%.

For the railroad signaling engineer, the Frankfort installation with its junction interlocking has become a milestone in the history of this branch of engineering in that it represents at the present time the largest and most up-to-date interlocking system on the European continent.

L-System 250 — a New Plug-in Busway System

By Peter Lenhart

In the past, busway distribution systems, i.e. bus systems with adaptable plug-in tapping boxes, have given very good service. In the course of further development the Siemens-Schuckertwerke have brought out a bus distribution system with a continuous current rating of 250 A at operating voltages of up to 500 V, thus filling the gap between the already existing bus systems for 125 and 400 A.

For the new busway (L-System 250, Fig. 1) it was possible to retain the tubular shape which proved successful with L-System 125 and thus also the suspension parts and tapping boxes for 15, 25 and 60 A.

Only the cross section of the busbars and the busbar supports had to be altered in order to meet the more severe conditions imposed by a continuous current of 250 A and the high mechanical hort-circuit strength of 35 kA (crest). This was achieved by means of shaped busbars of hard-drawn copper (Fig. 2) provided with milled slots to enable the use of the tapping boxes for 15, 25 and 60 A of the L-System 125. The enlarged surface of the shaped busbars also has an excellent cooling effect.

The new busway for 250 A (Table 1) can be used with a short-circuit fuse of 250 A in systems with a maximum short-circuit current of more than 100 kA rms. A possibly higher short-circuit current can be limited by low-voltage HRC (NH) fuses of lower current ratings.

The busbar supports (Fig. 3) had to be adapted to the shape of the busbars and designed for the

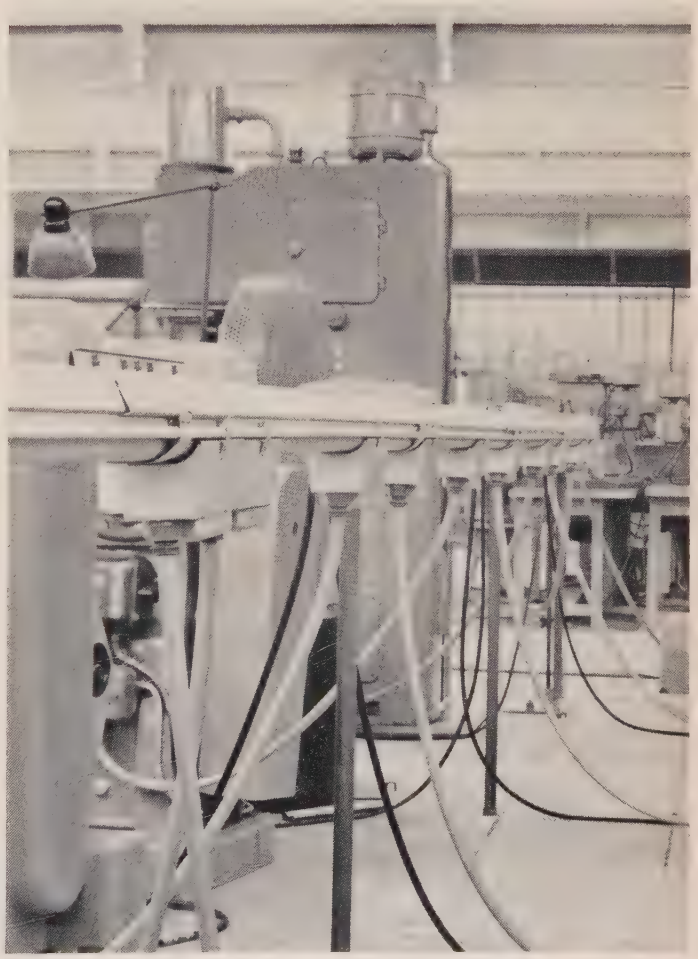


Fig. 1 Busway distribution system (L-System) mounted at a height of 1 metre (3 ft.) along a row of machines

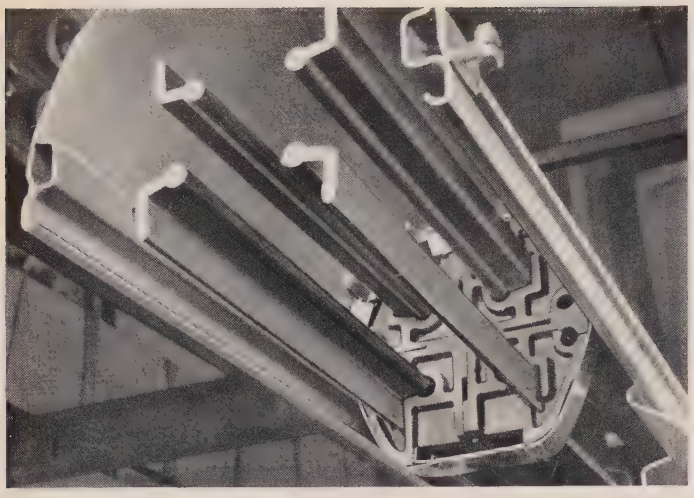


Fig. 2 Busway unit with shaped busbars installed (Busway trough removed)

Current rating	250 A
Voltage rating	500 V
Short-circuit strength (mechanical rating), crest value	35 kA
Max. current rating of short-circuit fuse	250 A
Type of enclosure	P 32 (DIN 40050)
Length of busway units	2,500 mm (8′3″) 1,750 mm (5′9″) 636 mm (2′1″)
Weight per metre	7.5 kg (5 lb/ft)
Plug-in tapping boxes with 2 socket outlets and one fusible base for Original-DIAZED* fuses	up to 15 A up to 25 A up to 60 A
for low-voltage HRC (NH) fuses	up to 100 A

* Trade-mark

Table 1 Technical data of the L 250 busway system

higher short-circuit strength of 35 kA (crest). They are made of moulded plastic and consist of four identical segments which, assembled together, form the bus support.

The fact that the continuous current rating has been increased to 250 A makes it possible also to connect several consumers with a comparatively high total connected load. Thus at an operating voltage of 500 V and a simultaneity factor of 0.5, for instance, a total of 42 three-phase motors each with an output of 7.5 kW can be connected. If power is supplied to the bus from both ends the number of loads connected can be doubled.

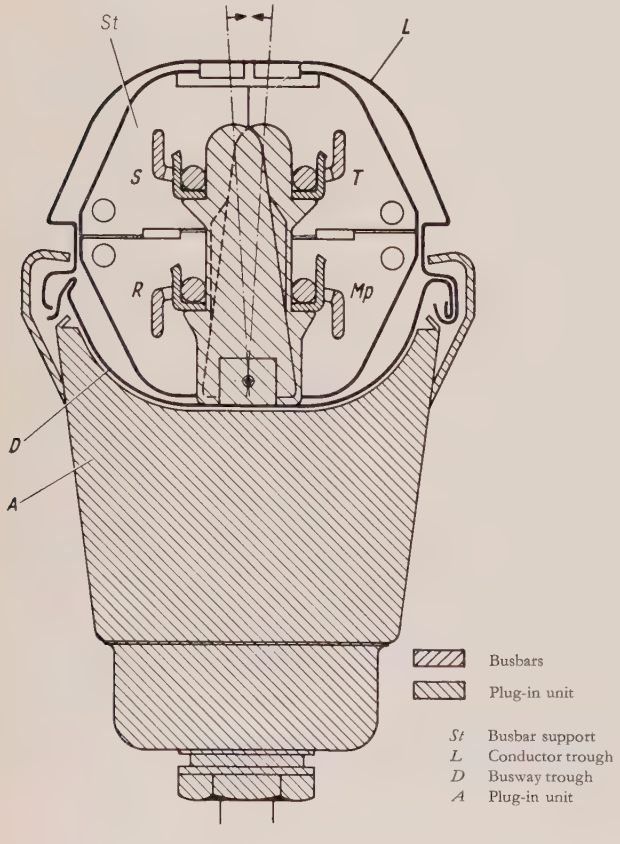


Fig. 3 Cross section of a bus unit with tapping box plugged in

If comparatively long rows of machines are to be supplied with power through one busway, the last part of the bus can consist of bus system 125 since the current-carrying capacity of the L-System 250 would not be fully utilized over the entire length of the busway. Here it should be noted, however, that a suitable fuse should be connected into the circuit ahead of the part of reduced cross section.

A unit length of 2.5 metres (8 ft. 3 in.) has been selected for the L 250 in order to reduce the material and installation costs per linear metre of a plant since, compared with the former unit length of 2 metres (6 ft. 7 in.) of the L-System 125, the number of suspension points is reduced (greater span length). A busway unit 2.5 metres (8 ft. 3. in.) in length has 9 tapping points which are 250 mm ($9^7/_8$ in.) apart and are closed by the sliding covers used also with the L 125.

The fact that the L 250 uses shaped copper busbars makes it necessary to supply the busway units with the busbars already installed; when installing, the bars are interconnected at the joints with the clamps supplied. The joints between the busway units are bolted together on the outside by means of connecting plates as in the case of the L 125.

If, at a later date, other bus sections are to be branched off from an existing 250-A busway system, tee or cross boxes provided for this can be installed together with an intermediate busway unit of 1,750 mm (5 ft. 9 in.) and

636 mm (2 ft. 1 in.) instead of a busway unit of 2,500 mm (8 ft. 3 in.) in length. The busway system already installed need not be altered to do this.

The feeder cables are entered longitudinally through the supply unit and connected directly to the shaped busbars by means of terminal clips (Fig. 4). In this way the unavoidable contact resistance and temperature rise are kept to a minimum.

Protodur* cables with round conductors up to a maximum of 4 × 95 sq. mm (4 × 0.147 sq. in.) and with sector shaped multi-strand (sm) conductors up to a maximum of 3 × 120/70 sm sq. mm (3 × 0.186/0.109 sq. in.) can be used as incoming feeder cables as long as their dimensions suit the Pg 48 Anthygron* gland.

Should the machines be so arranged that an angle of 90 degrees must be made in the busway (Fig. 5), an angle unit should be used. The connection of the busbars of the two busway sections is then established in the angle unit by means of single-core insulated cables with a cross-sectional area of 70 sq. mm (0.109 sq. in.). The jumper cables and busbars are connected by means of the terminal clips which are also used for the supply unit. In the case of the tee and cross boxes the connection is made in a similar way.

Like the L 125 system the L 250 is also protected against splashing water and the ingress of small foreign bodies (type of enclosure P 32 to DIN 40050). The L 250 busway should therefore be used mainly in dry and dust-free rooms.

To complete the manufacturing programme, a tapping box for low-voltage HRC (NH) fuses of size 00 up to a maximum rating of 100 A is provided, through which

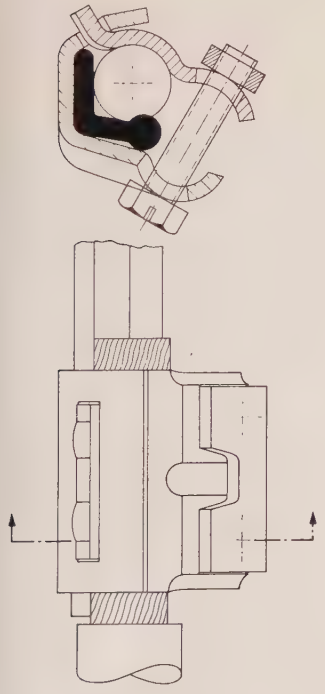


Fig. 4 Terminal clip for the L 250

even loads with more than 50 A continuously, e.g. three-phase motors with a rating of 53 kW for direct-on-line starting or 70 kW for star-delta starting and 500 V operating voltage, can be connected.

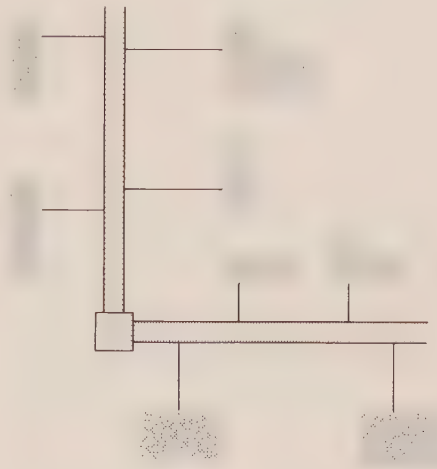


Fig. 5 Schematic representation of a busway distribution system with 90-degree turn

The main advantages of the busway distribution systems compared with previous methods of power distribution – versatility and flexibility in the connection of machines, the omission of masonry work and the reduction in installation work – can now be utilized with the L 250 system for heavier loads which could not be supplied by the L 125 but for which, however, the 400-A busway would have been too expensive.

The greatest advantage of the plug-in busway system is perhaps the fact that the electrical installation of, for example, a new factory hall, is no longer dependent on the final arrangement of the machines. In most cases modern machine tools are installed without special foundations and this modern method of machine tool erection results in a considerable reduction in the constructional work for the electrical installation (e.g. running of cables in the floor). The L-System affords area-wise distribution of electric power and the machines can be readily and simply connected up after the busway system has been installed.

If the need arises, the busway distribution systems can be combined with continuous rows of luminaires without the connection facilities of the L-System being affected in any way.

Experience already obtained with the L 125 has shown that no special training is required for the planning or installation of this busway system. It can be assumed with certainty that the L 250 busway, which has been developed from the L 125 system and uses the same proven components as the latter, will also prove to be a reliable busway distribution system.

* Trade-mark

Automatic Rate Recording Technique for Switchboard PABX's

BY WILHELM KURZ

Nationwide dialing has given rise to new aspects for processing outgoing long-distance traffic and recording message rates in PABX's. Whereas it is desirable that PABX extensions should have free access to direct distance dialing, it is also desirable that the proprietors of PABX's should be able to keep a check on the charges run up on such calls. The metering technique used in German nationwide dialing permits both demands to be met simultaneously.

Free access to direct distance dialing means discarding the digit suppressors hitherto used in the trunk relay repeaters of PABX's to bar access to long-distance dial service. To keep a check on message rates it is therefore necessary to record the meter pulses received from the public dial office. There are two automatic methods by means of which this can be done: either the meter pulses can be recorded by respective sum meters assigned to the various extensions without the calls being recorded individually [1], or a central recording unit (Fig. 1) can be used to record the following data for each long-distance call and, if necessary, each local call:

Number dialed
Call charge expressed in tariff units (converted, if necessary, into monetary units)
Number of calling party
Time of call (day, month, hour)

This technique is described in the following sections.

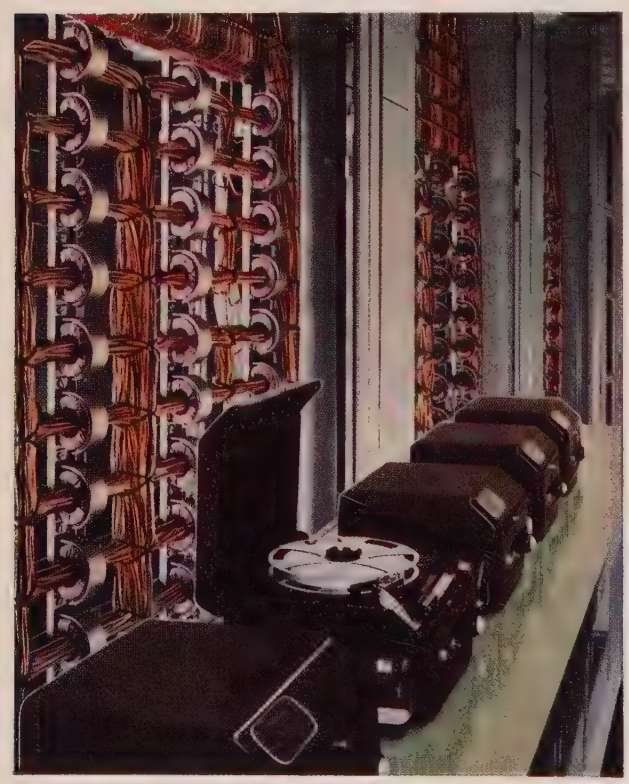


Fig. 1 The control equipment for automatic rate recording is installed in the switch room; the printers are installed in another room

Determining and storing data covering destination, call charge and origin of call

The PABX extension occupies a trunk (Fig. 2) by dialing 0 and makes a DDD call by dialing the area code followed by the directory number of the wanted party. These digits represent the destination of the call and, in order that they may be available for recording at the end of the call, are stored in a call-number storage (see Fig. 4). Since this storage is held in use for a long time for each call, each trunk relay repeater is permanently assigned one such storage. The digits – which may be up to twelve in the case of nationwide dialing – are stored in coded form.

The call charge is calculated from the number of meter pulses received from the public dial office. Metering begins as soon as the called party answers and ends as soon as either the calling or the called party hangs up. The meter pulses are received by the decimal rate storage. As the latter is capable of storing 900 meter pulses, it is able to cope with even the farthest German long-distance call lasting for some $2^1/_4$ hours and chargeable at the daytime rate.

The origin of the call – i. e. the code of the calling PABX extension – is determined by a central identifier. The connection is for this purpose traced back from the trunk relay repeater, through the various switching stages, to the subscriber line circuit. Either of two methods can be used. The first – for PABX's of all sizes – uses a superaudio a-c signal as an identifying criterion. The signal is transmitted backwards over the talking path and picked off a ring core array. Identification takes place

during the call. This method has already been described in detail elsewhere [2].

In the second method (Fig. 3), which serves for small to medium-size PABX's, d-c voltage is used for identification at the end of the call. A 4-armed 100-pt uniselector motorswitch tests its contacts to find the criterion. Each extension is assigned a separate contact in the contact field of the switch. The call number of the extension can be determined from the particular contact at which the identifying criterion is found.

With both methods the result of the identification process is first fed in coded form to the call-number storage. It is not recommendable that it should be fed straight to the printer. Owing to the interposed call-number storage, the identifier is able to operate irrespective of whether the printer is idle or busy.

Recording

By the end of the call, the information accumulated in the storage is complete. The storage calls, by way of an access selector (shown as switch in Fig. 2), for a control relay repeater, which in turn calls for all the items of information one after the other and passes them on to the printer (rate printer or perforator, see Fig. 2).

These operations are illustrated in Fig. 4: the rate perforator punches all the information into tape. The international telegraph code is used. After having been started by the control relay repeater, the perforator transmits control pulses to initiate the step-by-step advancement of a program chain by means of which the information in the storage and date-and-time transmitter and, in some

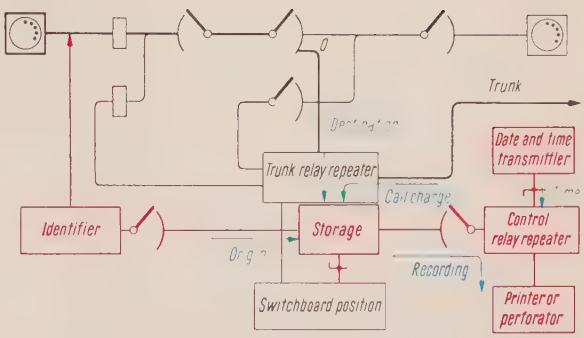


Fig. 2 Layout and operating principle of message accounting equipment (red) and transfer of information (blue) in a large PABX operating with EMD switches

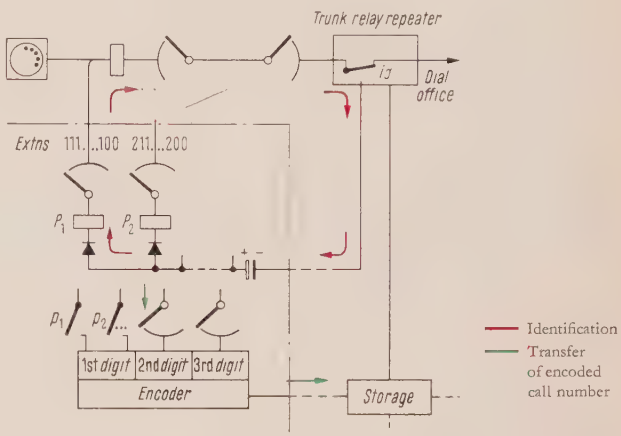
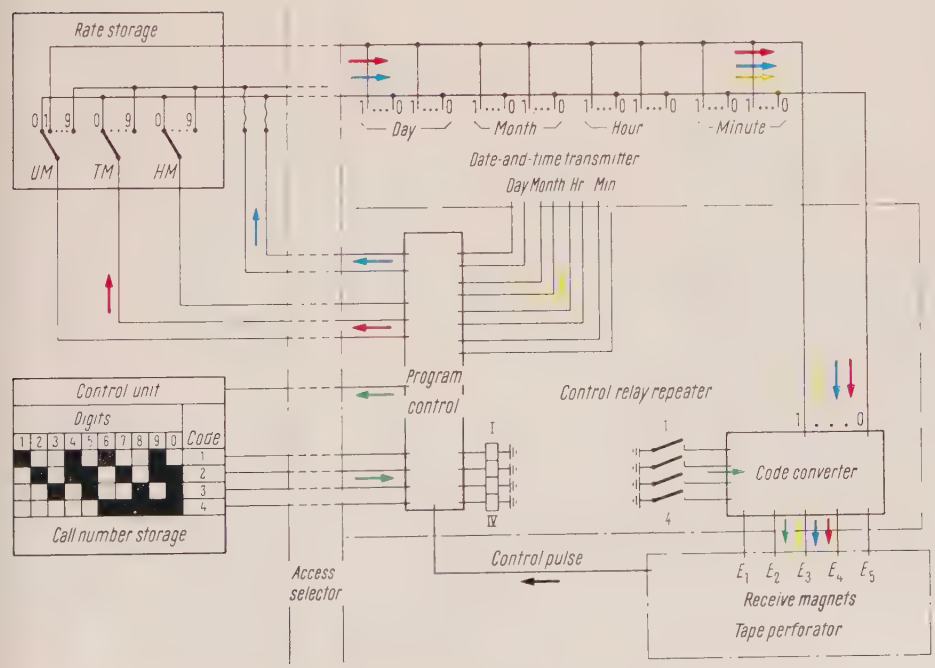


Fig. 3 Basic circuitry of switching equipment for identification with aid of finder



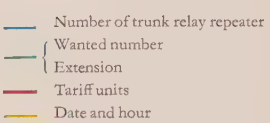


Fig. 4 Transfer of information from storage to recorder (tape perforator)

cases, also in the converter, are called for in a fixed sequence. Recording begins with the 2-digit number of the respective trunk relay repeater. It can be used for checking and testing purposes and is marked in the storage through a permanent cross-connection with a decimal number multiple. The tariff units are marked in the same multiple according to units, tens and hundreds by way of the rate storage. The stored numbers of the originating and the wanted subscriber are called for by way of a digit-code multiple. All these digits must be fed in coded form to the perforator. This is accomplished by a code converter to which the decimal numbers are fed direct and the coded digits of the call numbers are fed via the result relays I through IV.

If a rate printer is used, the control relay repeater is able to feed the decimal numbers straight to the printer; code conversion is confined to call numbers received in the 4-unit code.

The number of control relay repeaters and printers required depends on the printing operations that have to be performed. It can be calculated from the number of outgoing long-distance calls of the PABX in question. If several control relay repeaters are provided, they will share the use of a single date-and-time transmitter. If printing is not confined to long-distance calls alone, separate printers can be used for local calls in order to simplify accounting. It is also possible to have local calls printed only over long intervals.

Thus a complete record is obtained of all the data covering each individual call. This not only permits any desired form of message accounting, but also enables a check to be kept on all calls originated by the various extensions. An account of these potentialities is given in the following paper.

Bibliography

[1] Fath, W., Figur, S. and Kurz, W.: Die Technik der Gebührenerfassung in Fernsprech-Nebenstellenanlagen. Siemens-Zeitschrift **32** (1958) pp. 194 to 197

[2] Fischer, K.: A Semi-Electronic Identifier for Rate Recording in Large PABX's. Siemens-Review XXVII (1960) pp. 302 to 305

Automatic Message Accounting in Large PABX's

By Joachim Ventz

Accounting in large business organizations is today performed mainly with the aid of business machines. It would therefore appear logical to apply the same method to telephone call charges. Automatic message accounting with the aid of perforated tape in the manner here described covers all the principal data of a telephone call and permits data-processing in any desired form with ordinary commercial punched card equipment. The results already achieved show that automatic rate recording and accounting not only cuts operating costs but – despite easier access to DDD – even has the effect of reducing telephone bills.

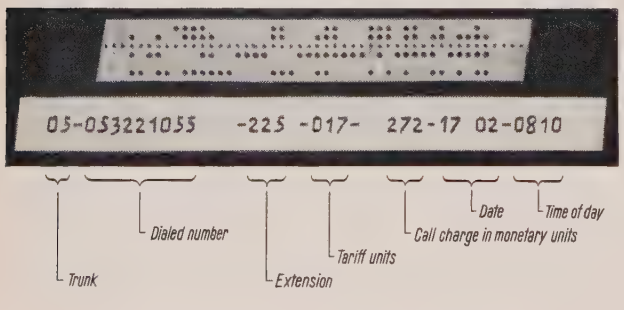


Fig. 1 Perforated tape containing call data (top) forms the basis of automatic message accounting. Below is a printed tape containing the same data.

Automatic message accounting

Fig. 1 shows a strip of perforated tape as it leaves the rate perforator. A strip of tape from a rate printer is shown below by way of comparison. Printing is used instead of perforation in cases where no provision is made for automatic accounting.

With the aid of the information contained in the perforated tape a pageprinter can be used to prepare a bill as shown in Fig. 2. A wide choice of methods for the automatic processing of perforated tape are offered by the punched card machines normally found in all large business organizations. The method chosen in any particular case will depend upon the general method of accounting of the respective organization and upon what particulars concerning the call are considered necessary by the management for the purpose of keeping a check on telephone call charges.

The accounting routine is basically as follows: the information in the perforated tape is converted by a tape-controlled card punch into punched cards. The call cards (Fig. 3) thus automatically prepared are now sorted according to extension numbers by a mechanical sorter; following this a collator merges the already sorted extension cards with the call cards. An extension card contains all the permanent data relative to the partic-

ular extension, especially the number of its charge account, and, if necessary, the letter code of the department, as well as any other particulars required for internal accounting. A reproducing punch punches the information into the call cards; after this the extension cards are resorted.

```
31+0311341541   +5625+018+29+12+1625+
04+0311660011   +0000+002+29+12+1625+
15+053140065    +6508+011+29+12+1626+
12+091315135    +2002+006+29+12+1627+
28+0212141881   +5781+032+29+12+1628+
04+0311660011   +5625+021+29+12+1628+
16+022042665    +2103+008+29+12+1629+
```

Fig. 2 Example of reproduction of call data by a pageprinter. The tariff units are not in this case converted into monetary units. The second and sixth lines refer to a call established by the switchboard attendant and afterwards transferred to extension 5625

Further processing depends largely on existing requirements. For instance, if it is further desired for the tariff zone or destination area of the call to be printed in uncoded form (see Fig. 4), the call cards must be sorted according to the punched area codes, merged with the area code master cards, and – once more using a reproducing punch – appropriately perforated. Card interpreters, electronic computers, statistical machines and other equipment offer further potentialities.

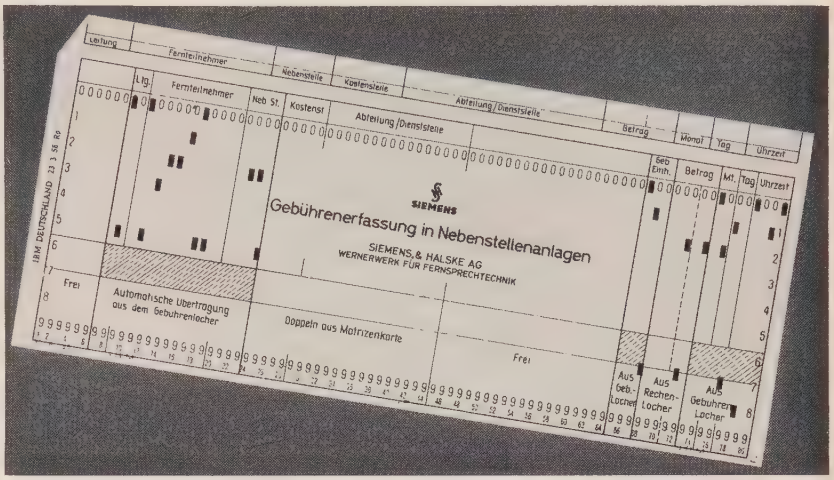


Fig. 3 Punched card (call card) obtained by processing perforated tape

Finally, the call cards are sorted according to charge accounts, extension numbers and date, and then fed to the tabulator, which tabulates the required data on a standard form (Fig. 4) and at the same time summates call charges per extension and charge account, and prints the total on the appropriate section of the standard form. If required, the number of calls can also be summated. In this way the management is able to keep a clear check on telephone calls, and especially on long-distance calls, originated by its PABX extensions.

Nachweisung
der Telefon- u. Gesprächsgebühren

Dienststelle	Apparat-Nr.		Tag	Mon	Uhrzeit	Teilnehmer-Nr.	Amtsbezeichnung/Teilnehmer	Zone	Gebühren DM pf

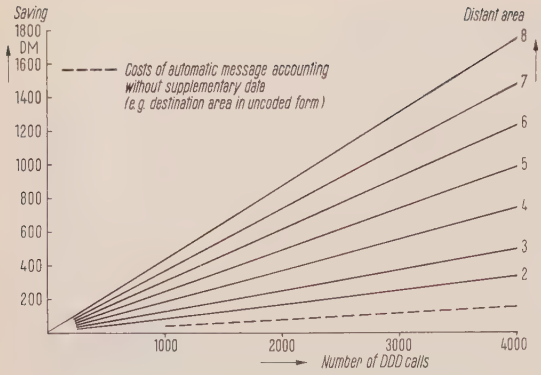


Fig. 5 Saving in call charges made possible by assigning PABX extensions access to DDD, thus eliminating the chargeable time expended by attendant on establishing long-distance calls and transferring them to originating extensions. An average delay of 23 sec is assumed.

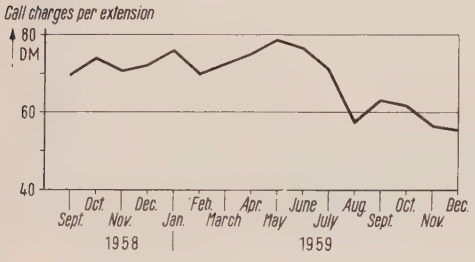


Fig. 6 Average call charges per extension and month in a large business organization

Advantages and results of automatic rate recording and accounting

Automatic rate recording leaves PABX extensions complete freedom in the use of their telephones. They are able to dial long-distance numbers in the same way as local numbers without the assistance of the switchboard attendant. They do not have to wait for the attendant to establish such calls for them. The flow of traffic is thus considerably smoother.

The management also enjoys a number of advantages: less switchboard positions and correspondingly less attendants are required (since a single position is able to establish about 45 long-distance calls per hour, it has up to now been necessary in the case of switchboard PABX's to assign several positions to outward long-distance traffic only). Automatic message accounting enables the management to maintain a clear check on telephone calls originated by PABX extensions at very little cost in manhours and equipment; telephone bills are also appreciably reduced.

The last factor is frequently underestimated: when a switchboard attendant establishes a long-distance call for an extension, she has first of all to request the long-distance party to wait while she completes the connection; then after recalling the extension, she has to wait for an answer. In many cases the extension is found busy, or the extension user has left the room. This delay, which averages 20 to 25 sec, naturally has to be paid for. The amounts that may here be involved are shown in Fig. 5. In comparison with this saving alone, the costs of automatic message accounting are negligible.

Contrary to what is generally believed, the assignment of DDD access to PABX extensions does not result in any increase in telephone bills as long as automatic rate recording and accounting is introduced. The statistics shown in Fig. 6 were placed at our disposal by a large business organization. Although all long-distance calls were established and recorded by switchboard attendants, the statistics show a rising tendency up to May 1959. Telephone bills drop during the vacation months of July and August, but never climb back to the previous level. The reason for this is that automatic rate recording and accounting was introduced at this point and PABX extensions were assigned DDD privileges.

The management attributes this welcome saving not only to the possibility of keeping a check on calls, but believes that extension users are discouraged from making unnecessary calls by the regular internal charge sheet they receive showing the amount of money they have expended "on the telephone" during the month. They not only feel themselves "called to account", but also develop a feeling of personal responsibility – a by no means unwelcome secondary advantage secured as a concomitant of technical progress.

New Transparent, Gasketless Sealing Ends for High-voltage Cables

By Otto Wichert

Ever increasing demands for electrical energy are accompanied by more stringent requirements with respect to the reliability of the power supply system, particularly in the case of high-voltage cable networks.

Apart from correct selection of the cable design, the operational reliability of cable networks depends on the quality and expert making of joints and connections, for which junction boxes, branch boxes and also cable sealing ends are required.

For paper-insulated mass-impregnated metallic-sheathed cables these sealing ends must be so designed that they provide adequate protection against the ingress of moisture and bleeding of the impregnating compound as

well as absolutely reliable electrical connection and high strength to withstand mechanical and dynamic stresses.

The new "Gasketless sealing end" (type designation EoD) manufactured by Siemens-Schuckertwerke fully meets these requirements (Fig. 1).

In contrast to the single-conductor box-type sealing ends hitherto used indoors for 20 and 30 kV with which the porcelain bodies are jointed to the upper and lower metallic parts of the sealing ends by means of screwed or cemented gaskets, the gasketless sealing end has an insulator of hot-setting transparent cast resin, which has a high dielectric strength. Cast into the top and bottom of the cast-resin insulator are two tinned brass tubes.

Installation is very simple. As soon as the usual work on the cable and on the core ends has been completed, including the soldering of the conductors to the connecting studs, the tube protruding from the bottom of the cast-resin cylinder can be joined to the metallic sheath by means of a wiped joint. Following this, the joint between the metal collar of the copper connecting stud and the brass tube projecting at the top of the cast-resin cylinder is sealed off by a narrow soldered seam. This provides all the sealing necessary and obviates the need for the conventional gaskets which were often a source of trouble.

The sealing end is filled with impregnating compound of medium viscosity through a hole provided in the connecting stud. This is then closed off by a fine-pitch metallic plug, which, if necessary, permits topping up of the compound without opening up the sealing end.

Since the insulating body is transparent it is a simple matter for the attendant to check the level of the compound in the sealing end.

Where the difference in the level of the cable run is appreciable or if there are heavy fluctuations in the load carried by the cable, the impregnating compound may migrate from the ends of the cable, thereby reducing the dielectric strength and giving rise to the danger of an electrical breakdown. In such cases the compound flows from the sealing ends into the cable thus restoring the dielectric strength of the cable and maintaining its operational reliability.

Fig. 2 shows the termination of a 20-kV S.L. cable with the new sealing ends. While the level of the compound in the insulators of the two outer phases is normal, it can quite clearly be seen that the level in the centre phase has fallen and that it must be topped up.

The sealing end is designed for installation in a vertical position; however, it may also be inclined up to an angle of 30° to the vertical. The EoD is primarily intended for the termination of 20-kV and 30-kV single-core, S.L. and H.S.L. cables in indoor installations. With the aid of the accessories specially designed for this purpose, the sealing ends can also be used within the same voltage range for belted cables, H-type cables, single and three-core oil-filled cables and for internal-gas-pressure cables.

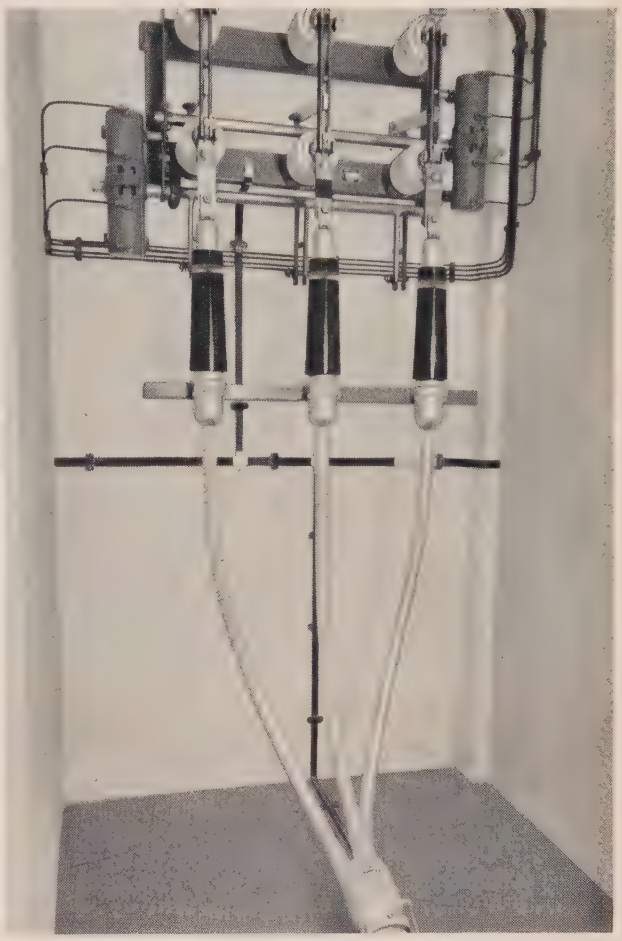


Fig. 1 Sealing end group EoD 20 terminating a 20-kV S.L. cable

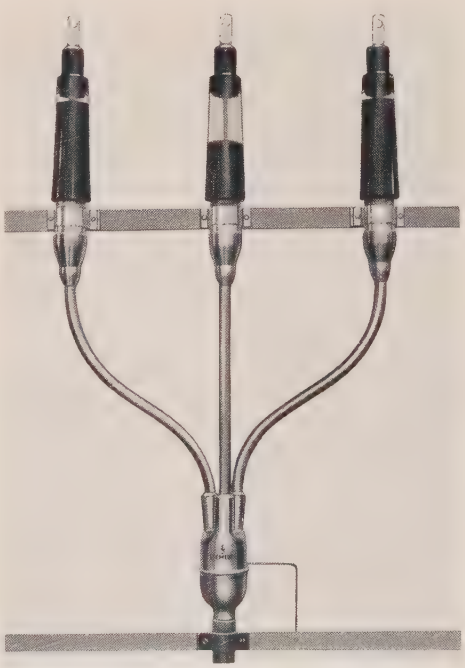


Fig. 2
EoD 20
on a 20-kV
S.L. cable

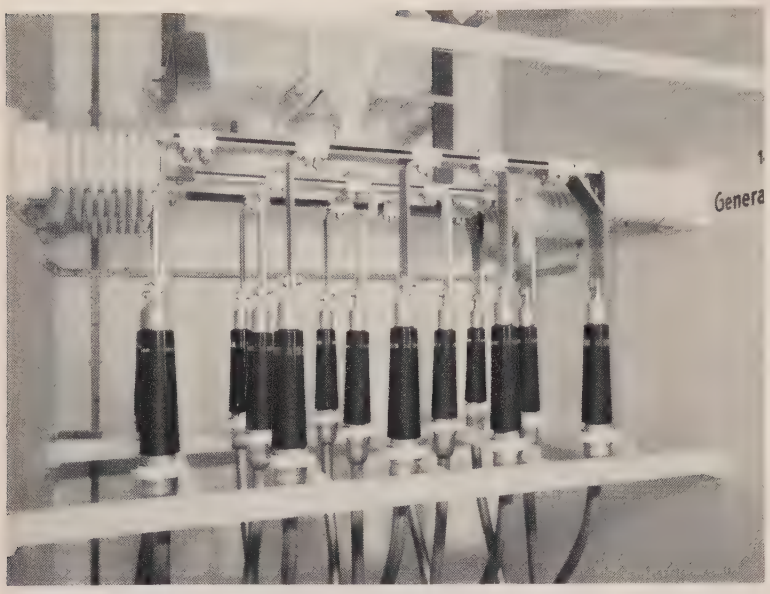


Fig. 3 Sealing end groups EoD 30 terminating 25-kV S.L. cables in a switchgear cell

capable of withstanding surge currents of up to 25 kA. If a cast-iron spreader box is used, the sealing end group can withstand surge currents up to 100 kA. This capability can be increased still further up to 150 kA if lateral kinking is prevented by clipping the cable cores to a horizontal strip arranged between the spreader box and the sealing ends.

Since the gasketless sealing end requires little space, it is given preference in many locations, particularly in switching stations. Its versatility also simplifies stock-keeping. A further advantage is that it can be installed easily and quickly by every trained cable fitter.

The new sealing ends have received considerable attention from electrical engineers, especially as they are better technically and less expensive than porcelain sealing ends of comparable size.

Fig. 3 shows 25-kV S.L. cables with EoD sealing ends installed in a switchgear cell.
In the standard design a lead cap is employed to spread the cores. This arrangement makes the termination

The experience gained with the many hundreds of EoD sealing end groups installed in distribution systems and in industrial plants has fully justified the confidence placed by engineers in the new design.

Shortwave Receiver of High Frequency Accuracy for Fixed and Mobile Radio Stations

By Gerhard Pilz

For radiocommunication across long distances recourse is taken for the most part to shortwave operation. The steadily growing number of radio services and the wide range of shortwave radio call for transmitters and receivers of great frequency accuracy. Moreover, the SSB technique that has been used for decades for transoceanic radio links has in recent years found increasingly wide acceptance for mobile radio stations as well.

The Rel 445 E 311 shortwave receiver (Figs. 1, 2, 3) was specially developed for this technique. It is a versatile receiver for the following classes of emission: A1 (c-w telegraphy), A2 (modulated telegraphy), A3 (DSB telephony), A3a (SSB telephony with or without reduced carrier). With the aid of supplementary equipment the receiver can also be adapted for F1 and F6 operation (telegraphy with frequency-shift keying with one or two channels) and for A4 and F4 operation (a-m or f-m facsimile).

A notable feature of the receiver is its netting accuracy of 100 cps for any frequency from 1.5 to 30 mc. For instance, to receive a station transmitting at 11.3765 mc, the coarse scale is used to select 11.3 mc and the vernier scale to select 76.5 kc. The vernier scale (0 to 100 kc) operates with a decimal counter marked in divisions of 100 cps per millimeter. The receiver thus has an effective scale width of 285 m. Providing the field strength at the point of reception and the noise level allow reception, any shortwave station can be heard over the built-in loudspeaker after tuning in its frequency without having to search for it on the scale. The frequency stability of the receiver is better than 20 cps over 24 hours. These netting accuracy and stability values required for the transmission of speech without a pilot carrier are a considerable achievement for a shortwave receiver with a space requirement of only 1.5 cu. ft and weighing just under 53 lbs.

The coarse scale is assigned a continuously tunable heterodyne oscillator for use if a station has to be sought rapidly over a broad section of the scale. Otherwise this 1st converter is synchronized by the frequency spectrum of a

Fig. 1 The Rel 445 E 311 shortwave receiver

highly accurate crystal and then furnishes discrete frequencies spaced 100 kc apart in correspondence with the setting of the coarse scale. Synchronization is indicated by a lamp. The vernier scale is assigned the frequency-linearized 2nd converter which, like the 100 kc crystal, is thermostatically controlled. Finally, the frequency-switching of a 3rd converter permits selection of the less disturbed sideband from a disturbed DSB speech transmission. The 4th converter serves either for receiving c-w telegraphy or for restoring the carrier to the received SSB transmission. Like the 3rd converter, it is crystal-controlled for all classes of emission.

Four continuously tunable r-f circuits are provided for front-end selectivity. They suppress all image frequencies by more than 80 db. The receiver oscillator voltage at the unbalanced antenna input (60 ohms) is less than 20 microvolts. The receiver operates with the intermediate frequencies 1300 to 1400 kc, 370 kc and 30 kc. Particular attention was devoted to providing immunity from spurious signals and heterodyne whistles. In the 30 kc position the receiver bandwidths ± 150, ± 500, ± 1500 or ± 3000 cps are established with multiple-tuned ferrite filters. These filters are designed as printed circuits. The SSB filter, which is of similar design, has a passband of 3.5 kc. For SSB reception, a product demodulator is used.

Pulse-type disturbance can be partially suppressed with a bipolar noise limiter controlled by the amplitude of the audio signal. It is also effective for SSB reception. The receiver has a squelch with an adjustable threshold. This is of advantage for the transmission of speech without a pilot carrier and for c-w telegraphy. Five different automatic control voltages stabilize the audio output level at ± 3 db if the receiving voltage fluctuates between 5 microvolts and 500 millivolts. The automatic fading control has a selectable time constant and is also effective for SSB reception.The 1st converter and its synchronizing attachment draw plate voltage from a voltage regulator that operates with a power transistor. The frequency

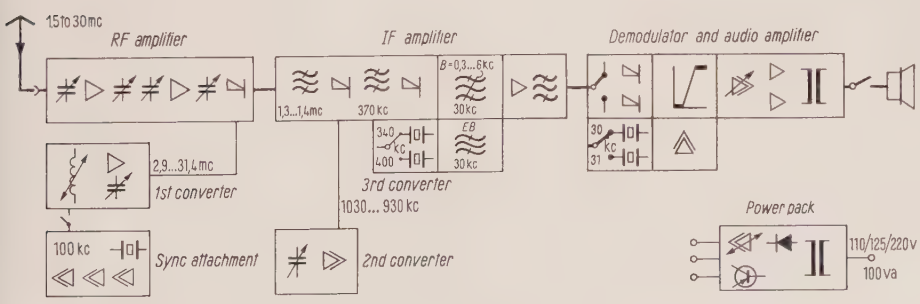


Fig. 2 Block schematic of receiver

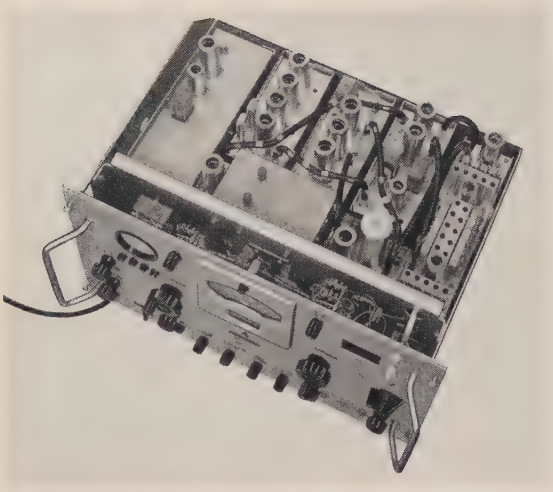


Fig. 3 Receiver with cover removed

scales of the receiver can be recalibrated at any time with the aid of built-in calibration facilities. The absolute frequency accuracy of the receiver, which depends largely on the 100 kc crystal, can also be checked against standard frequency emissions.

The receiver, which is capable of withstanding vibration and mechanical shock, is composed of seven subassemblies, some of which are of plug-in design. Wide use is made of printed circuits. It is equipped with only 16 tubes (three international types) and can be used in the temperature range of −20 to +50 °C. Power supply voltage fluctuations of −15 to +10% will not impair its high frequency accuracy. Power consumption during the warmup period is approx. 100 watts, which drops to about 70 watts when the thermostat is switched off (pilot lamp on front panel). A transistor inverter has been developed to permit feeding from a 24-volt battery.

Two-stage Arc Quenching in High-voltage Switching Stations up to 30 kV

By Friedrich Meyer

The installation of arc-quenching units in high-voltage switching stations up to 30 kV provides complete protection against the effect of arcing faults [1]. This method, by which the arc is short-circuited within a period of 10 milliseconds, and the arcing energy thus limited to values which are not dangerous, involves only short-time interruption of the station or section concerned. The advantage of arc quenching is that it not only obviates the accident hazard, which would otherwise be present due to free burning out of the arc, but also prevents damage to the equipment.

The two-stage arc-quenching method described here ensures in the majority of cases that the station is again ready for service within 0.5 seconds of the arc-quenching unit having operated. In a manner similar to that in which arcing faults are quenched on overhead lines by rapid reclosure, the two-stage arcing units short-circuit the switching station affected only until the arc path has been de-ionized. Extensive experiments have shown that the arc path can be fully de-ionized if it is short-circuited within 10 milliseconds of the arc striking.

Arc quenching in two stages

When an arc is struck in a station, stage I of the arc-quenching unit is initiated via photoelectric diodes and an automatic selecting device, thereby short-circuiting the arc within 10 milliseconds (Fig. 1). After a preset time (approx. 0.2 seconds) the circuit breaker associated with the arc quenching unit receives a tripping signal and interrupts the short-circuit current. If by this time the cause of the arcing fault has been removed and the path of the arc de-ionized, the full system voltage will return to the station. The control impulse for the circuit breaker can either be taken from an overcurrent-time relay interconnected with this circuit or from a time-storage element in the automatic selecting device.

The object of the second-stage arc-quenching unit is as follows:

1. To quench the arc should it restrike following the completion of the switching cycle of the first stage.
2. To cover the possibility of the first-stage unit being disconnected from the operating voltage by the line-side isolating switch or circuit breaker, even though otherwise ready for operation.
3. To cover the period between the operation of the first-stage unit and its being ready for service again (changing of the glass covers on the contacts and tensioning of the closing springs) in the event of an arcing fault again developing in the station.

Criteria for the selection of the arc-quenching unit

When the light response value of the photoelectric diode nearest to the arc is exceeded, the digital output signal of the associated snap-action electronic amplifier AV is evaluated in the automatic selecting device AM within a few microseconds. It is then transmitted to the operating coil of the arc-quenching unit via the output amplifier. The additional signals required for the selection of

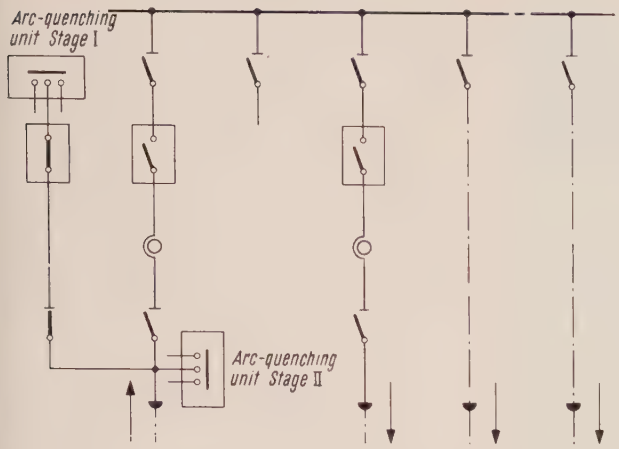
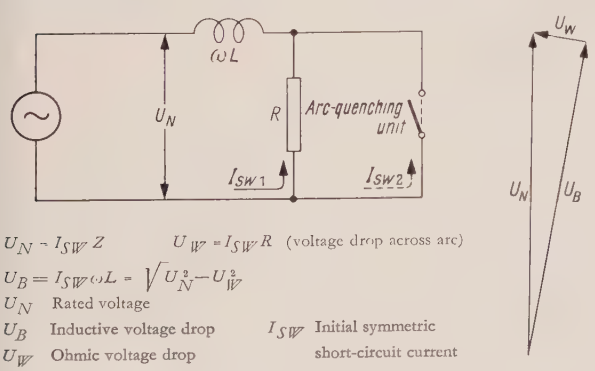


Fig. 1 Basic circuit arrangement for two-stage arc quenching

the first-stage arc-quenching unit are passed to the automatic selecting device as intelligence. If, for instance, in a station with a double bus system there is a signal to the effect that the voltage U_{SSI} of bus I is 0 at the instant a signal is received from the electronic amplifier AV, the selection of the arc-quenching unit for this bus is blocked. The same procedure can be adopted if this voltage is signalled as the rated voltage U_N. Only when U_{SSI} is not equal to 0 and U_N, i. e., the voltage has collapsed to the value of the voltage drop across the arc, is the operating signal released for the associated arc-quenching unit through the medium of a simple "And" element [2]. The short-circuit current flowing via the bus into the arc can also be employed as a criterion for the selection process. The arc-quenching unit is then operated by light and overcurrent. This provides clear selectivity from other busbars through which no short-circuit current is flowing.

In the case of stations having no arc barrier between the bus and the isolating switch, the diodes of the isolating switches start the arc-quenching unit when there are short-circuits on the bus. In this arrangement provision must be made for selective operation of the arc-quenching units, taking into account the voltage in the bus systems. In switching stations with an arc barrier, diodes are required for the busbars, a separate starting electronic amplifier being allocated to each system. In this manner good selectivity is obtained.



$U_N = I_{SW} Z$ $\quad U_W = I_{SW} R$ (voltage drop across arc)

$U_B = I_{SW} \omega L = \sqrt{U_N^2 - U_W^2}$

U_N Rated voltage

U_B Inductive voltage drop $\quad I_{SW}$ Initial symmetric short-circuit current

U_W Ohmic voltage drop

Fig. 2 Voltage vector for the short-circuit path

Single or two-stage arc quenching

Since the arc-quenching units of the first stage employ a circuit breaker for short-circuiting the arc, a complete switching cubicle is required for their installation. It should be decided from case to case whether the additional expenditure for a second-stage arc-quenching unit is justified in view of the relatively infrequent occurrence of an arcing short-circuit. Where the switching stations feed essential loads it is advisable to provide two-stage arc quenching to ensure that conditions are satisfactory when the voltage returns to the busbars after the arc has been quenched.

Stressing of the equipment due to arc quenching

A problem which has been raised is whether the metallic short-circuiting of the arc gives rise to higher stressing of the station switchgear or of the feeder transformers and of the generators. In considering this it should be remembered that the arc-quenching unit only short-circuits a small non-inductive resistance component of the short-circuit impedance (Fig. 2). With an almost constant voltage of 1 kV for the arc path, the ratio for an arc struck between two phases is as below:

$$\frac{\text{Short-circuit current flowing via the arc-quenching unit}}{\text{Short-circuit current flowing via the arc}} = \frac{U_N}{\sqrt{U_N^2 - 1}} \qquad (U_N \text{ in kV})$$

From this the stress is increased by less than 1% at a rated voltage U_N of 10 kV, 1.5% at 6 kV and 2% at 5 kV. Apart from the fact that the equipment and machines have to be designed to withstand full short-circuit currents, i. e., for dead short-circuits at the terminals, the difference made by an arc is completely unimportant.

In the article listed under [1] reference was made to the fact that an arc is always initiated at near to the maximum voltage when the dielectric breaks down between two phases. As a result of this, the d. c. component is generally fully or partly suppressed. It should be remembered that in the case of a short circuit between two phases the short-circuit current is $\sqrt{3}/2$ lower than that flowing with a short-circuit between three phases, that is of course until the instant when three-phase arcing takes place.

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Siemens Nürnberger Zählerwerk

By Franz Giehl

The Nürnberger Zählerwerk has been in existence for some 75 years. It employs a staff of highly trained personnel and is equipped with all special machine tools and testing equipments required for the manufacture of electricity meters, time switches and accessory equipment.

Modern production lines with automatic testing equipment turn out large numbers of single-phase and three-phase meters for every commercial metering range and fit them with a variety of registers, terminal blocks and casings. Each meter is calibrated on automatic test stations in accordance with the regulation in force in the country where it is to be used.

The same care is taken in the manufacture of small quantities of precision type electricity meters, meters with tariff mechanisms, time switches and accessory equipment. These instruments serve for the metering and billing of bulk electrical energy which is fed, for example, from generating stations into the public supply system or from this to industrial undertakings.

The high standard of quality of the precision work gives the products of the Nürnberger Zählerwerk the long life and the high accuracy in measurement for which they are well known.

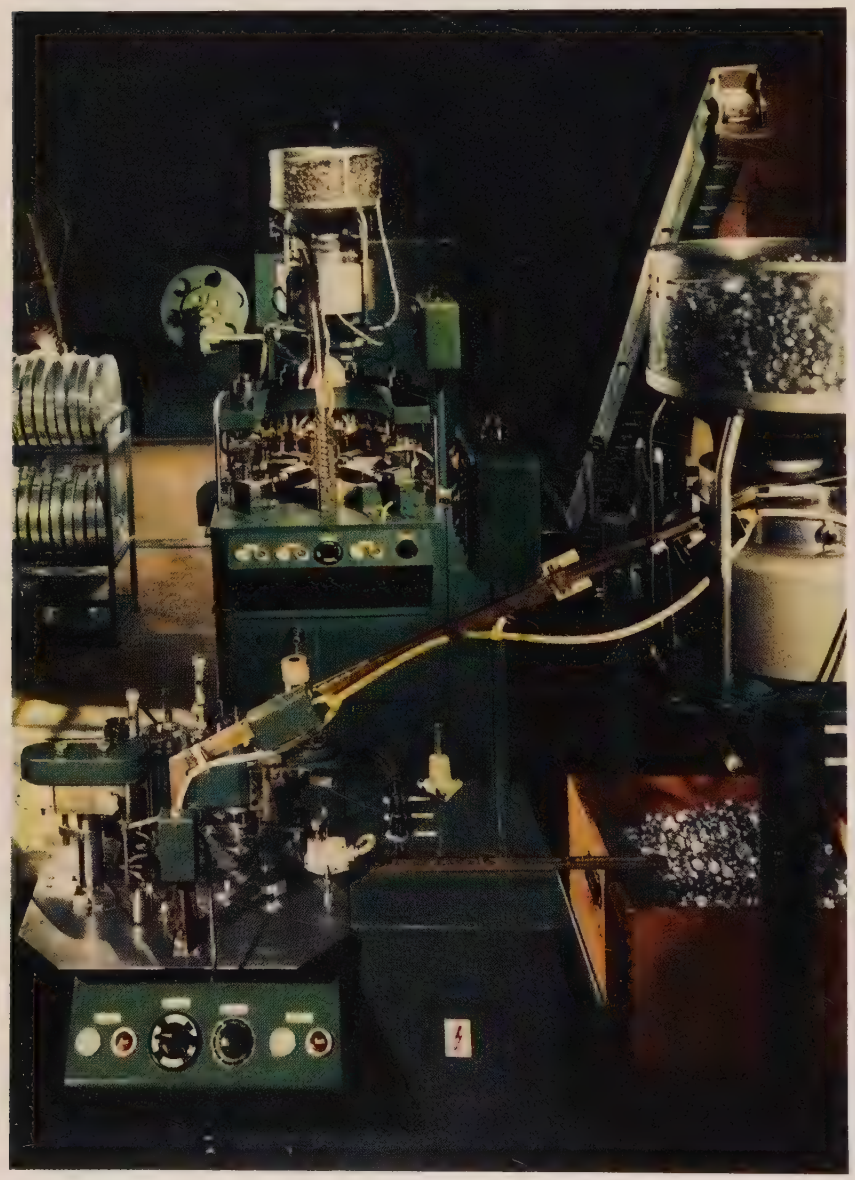
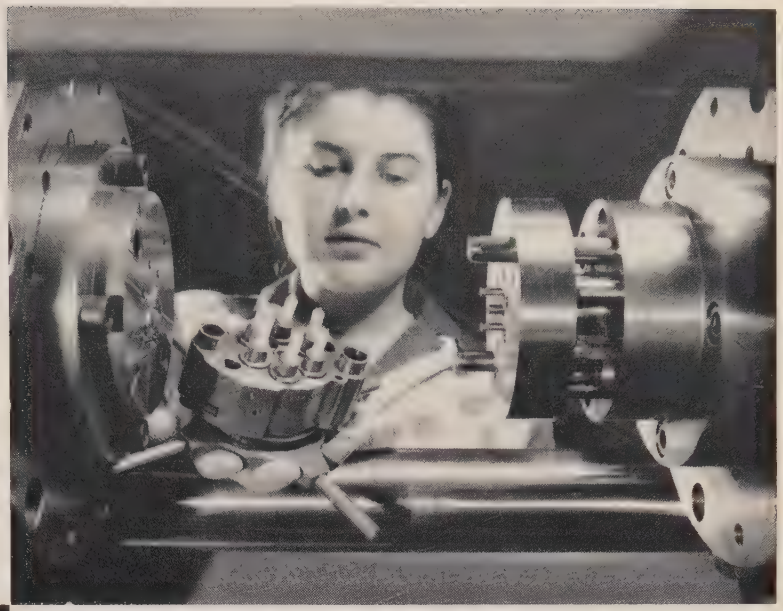


Fig. 1 Production line for figure drums. Cyclometer registers are preferred for electricity meters because they are easier to read than pointer type registers. The light aluminium figure drums with their narrow oil-free running faces provide a very low frictional torque and are distinguished by their constant friction values. The large demand for figure drums can only be satisfied by the use of special automatic machine tools arranged to form a production line. The product is subjected to a special test after each machining operation until it is finally completed.

Fig. 2 Injection moulding machine. When employed at the right place injection mouldings show a very slight degree of wear and friction and are superior to all materials hitherto known, such as steel, brass, aluminium and laminated fabrics. In the Nürnberger Zählerwerk therefore, gear wheels, worms, wormgears and bearing bushes are made from these special mouldable thermoplastic materials. Large, heavy injection moulding machines eject from multi-unit moulds dimensionally accurate, highly polished parts.



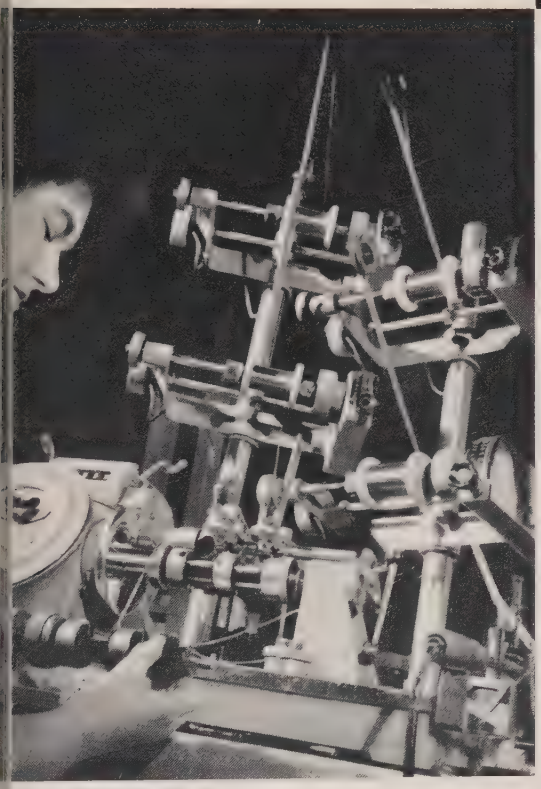


Fig. 3 Winding machine for voltage coils. The voltage coils which are wound without a paper spacer between layers have an excellent filling factor and contain a minimum of copper; this makes for particularly low temperature and frequency errors in the electricity meters. The insulation of the wire used for such coils must be of high grade. Several coils are wound simultaneously on the winding machines.

Fig. 4 Assembly of single-phase meters. The single-phase and three-phase meters are assembled in special rooms which are separated from the other manufacturing departments. The current and voltage electromagnets with rotor disc, bearings, brake magnets and register are assembled on modern production lines. The adjustment of the air gaps, rotor clearance and gear meshing is checked by projecting a greatly magnified picture onto a special screen. Assembly also includes a preliminary stroboscopic adjustment of the meters with rotating substandard meters.

Fig. 5 Assembly of maximum demand mechanisms. The account for the electrical energy supplied often includes, in addition to the charge for the energy consumed in kWh, a charge proportional to the maximum demand in kW. Energy and demand are registered and indicated by kWh meters fitted with maximum demand indicators and frequently also by duplicating registers with indicating, recording, printing or punching mechanisms. The duplicating registers are operated by the impulses from impulsing meters. The maximum demand mechanisms are assembled from precision machined component parts and adjusted by means of gauges and micrometers.

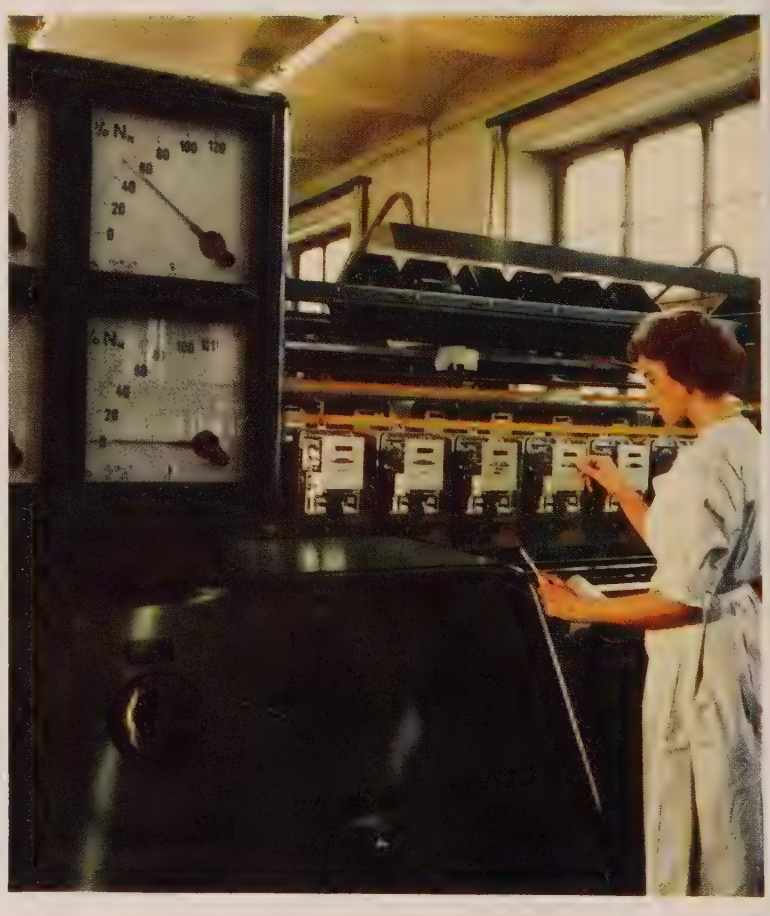


Fig. 6 Meter calibrating station. A high degree of accuracy in measurement is required from the precision type meters and from the wide-range meters so often used in single-phase and three-phase installations. Specially developed calibrating stations with adjustable rotating substandard meters, torque balances and voltage symmetry indicators ensure optimum adjustment. Each meter is calibrated in accordance with the regulations in force in the country of destination.

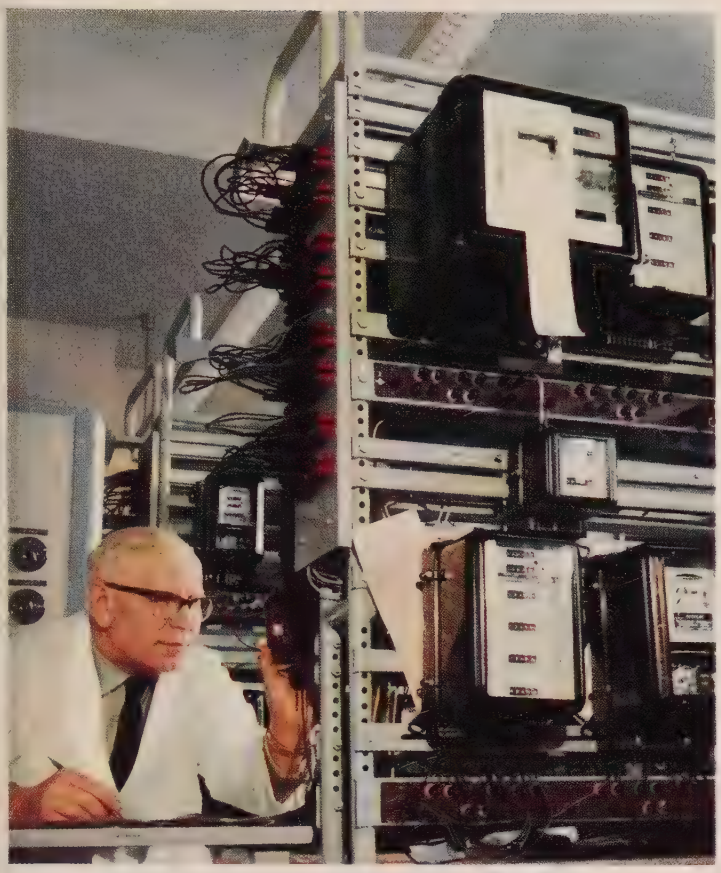


Fig. 7 Testing station for duplicating registers. Duplicating registers which are fitted with various tariff mechanisms are used for metering bulk energy. Fault- and disturbance-free operation is an indispensable prerequisite for their application at the metering points. Great care is therefore taken in subjecting the instruments to a long-term test for dependability and operational reliability. Certificates containing the test results are furnished with each duplicating register as proof of its having passed a test for correct readings and proper functioning.

Fig. 8 Meter storeroom. Tens of thousands of meters for the orders on hand are stocked in large storerooms, where they are made into complete consignments, provided with rating and proprietary plates as requested by the customer and forwarded to the packing department.

NEW EQUIPMENT

Automatic Contactless Control of Slurry Silos

By WALTHER KIRCHNER

In wet-process cement mills compressed air is blasted into the slurry silos at regular intervals to thoroughly mix the raw slurry and prevent the deposition of suspended particles. A newly developed automatic programme control effects the air blasting to a definite time schedule. For this purpose solenoid valves are installed in the air-blast lines of the individual silo compartments and are opened and closed in accordance with the programme set in the control unit. Adapted to practical requirements, the control unit can be used for controlling the air blast for as many as six compartments or even more if an accessory unit is employed.

The newly developed control unit relinquishes the idea of establishing the programme by means of controller drums or selectors. Since the wet process is mainly used in tropical regions and overseas, the slurry silo control must satisfy the stringent requirements associated with this type of service. In such countries experienced labour is rarely found for the maintenance of automatic control systems. The slightest defect on a moving part of a control system, built up of conventional elements, often results in a stoppage of the complete automatic control since the equipment has to be removed and sent to a competent workshop for repairs. An important feature of the new control is therefore that it contains only contactless elements and no moving parts which are subject to wear, except for incandescent lamps used as indicators; thus neither servicing nor maintenance is required. In place of relays or rotary selectors SIMATIC* building blocks are used, which consist of transistor circuits, thus ensuring unrivalled reliability in operation and freedom from maintenance. These elements also make it possible to adapt the control to the given operational conditions.

The duty cycle of the control consists of six successive air blasts per slurry compartment. The programme operation starts with the first compartment and after the completion of six air blasts changes over to the next compartment (Fig. 1). After all compartments have been air-blasted, the duty cycle is again commenced at the first compartment. The blast periods, the intervals between the individual blasts and also the pauses, during which changeover to the next compartment takes place, can be set from the outside by means of a rotary knob on a 24-point rotary switch.

The following switches and pilot lamps are also arranged on the front panel of the control box (Fig. 2):

1. A mains switch to energize the control unit. The control handle of this switch is fitted with a pilot lamp which lights up when the unit is energized. Turning this switch causes the programme sequence to be switched on and off.
2. Six three-point switches, one for each compartment, providing the following functions:

   The silo compartment is included in the air-blast programme.

   The compartment is removed from the programmed sequence of operations; this is expedient if, for instance, the compartment is empty.

   The silo compartment is continuously air-blasted in a fixed cycle irrespective of the programme; this is required when material is being drawn from the compartment; the air-blast effects a uniform quality of the product.

* Trade-mark

T_1 Air-blast period adjustable between 10 and 60 secs.

T_2 Interval between two shot blasts, adjustable between 10 and 60 secs.

T_3 Interval for changing over the air-blast programme to the next silo compartment, adjustable between 8 and 180 secs.

Fig. 1 Operating cycle of the slurry silo control

Fig. 2 Slurry silo control unit

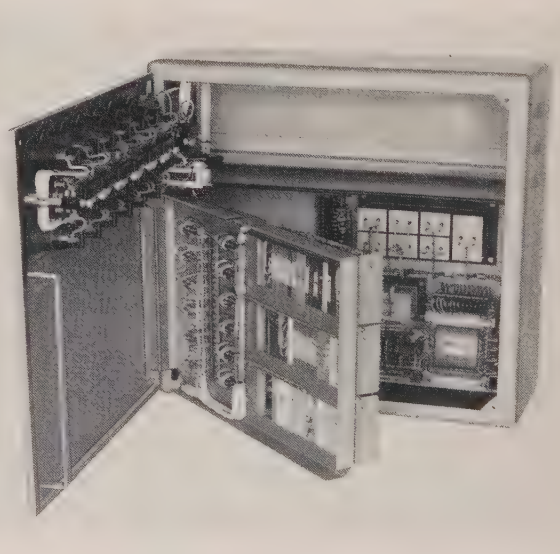


Fig. 3 Slurry silo control unit. The SIMATIC building blocks are arranged on a hinged chassis

3. Six pilot lamps (green) the lighting up of which indicates that the associated compartment is being air-blasted as programmed. The lamps also light up if the three-point switch for the compartment is set to the position "Continuous blast".
4. One pilot lamp (red) indicating "One air-blast valve open".
5. One pilot lamp (yellow) indicating "Air-blast interval".
6. One pilot lamp (blue) lighting up during the pause required for changeover from one compartment to the other.

As already mentioned the individual parts require no maintenance; in spite of this, great importance has been attached to easy accessibility of the individual SIMATIC components. They have therefore been arranged on a hinged chassis so that they can be reached from either side while being mounted in place. This makes in particular for a space-saving arrangement (Fig. 3).

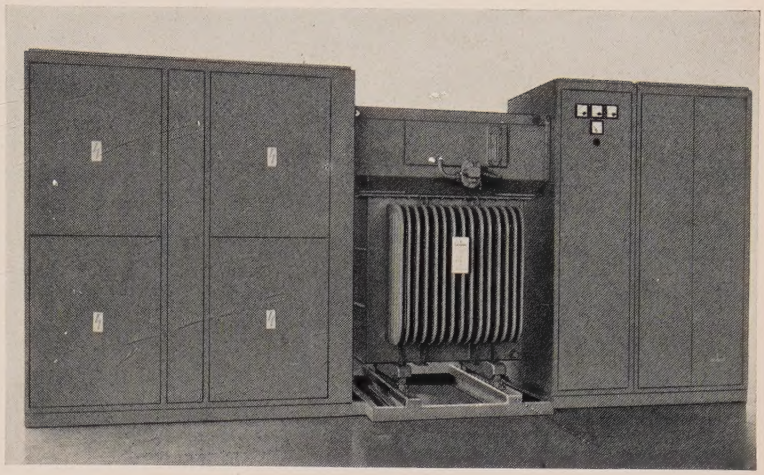


Fig. 1 315-kVA load-centre unit substation, insulation rating 10 kV

The control unit is so designed that the solenoid valves controlling the air-blast operations can be directly connected without interposing contactors and relays (24 V d. c., 36 W maximum). The connected load of the complete unit is 150 VA at 220 V, 50 c/s.

Load-centre Unit Substation for 100 to 250 kVA, Insulation Rating 10 kV

BY KONRAD BECKER

In cities and industrial concerns extensive low-voltage systems are required for the supply of electrical power. In view of the high degree of reliability required, these are generally of the interconnected network type and are connected to high-voltage ring mains via transformers whose number and rating are determined by the load per unit area. Particularly suitable for this application are load-centre unit substations with ratings from 315 to about 500 kVA which are constructed on the building-block principle and consist of a flange-type transformer with built-on high and low-voltage cubicles. Since the live parts are completely enclosed by a sheet-steel cover, separate rooms are not necessary and they can be installed anywhere, including basements (Fig. 1). There are, however, many large individual consumers and small systems, e. g., urban systems, for which smaller stations with less comprehensive equipment are adequate. For such cases Siemens have specially developed a smaller range of load-centre unit substations which can accommodate transformers with ratings of 100, 160 and 250 kVA at voltages up to 10 kV, and which are suitable for connection to radial lines or ring mains (Fig. 2). Their basic construction is the same as that of the larger load-centre unit substation, i. e., a flange-type transformer is used onto which the equipment cubicle is built. The flange of the transformer is located on the same side as the high-voltage bushings, the cooling tubes being omitted on this side on account of the equipment cubicle. In order to provide adequate cooling, the cooling surface on the opposite side and at the two ends is increased. Where the full output is required, normal transformers cannot be used with this arrangement owing to the limited dissipation of heat.

Arranged on the high-voltage side of the transformer are HRC (HH) fuses which serve as short-circuit protection. Since it must be possible for the personnel to change these fuses without being exposed to danger, or to remove them to isolate the transformer, the fuses are fitted to carriers arranged on a hinged flap with handles. With this flap the fuses can be fully drawn out of the mating contacts away from the high-voltage supply and changed outside the cubicle. In order to prevent accidental contact with the live contacts in the cubicle, an insulating shield with cutouts through which the fuses are drawn can be arranged in front of this.

The fuse isolator with the HRC fuses described is intended to open the transformer circuit when off-load. To make the opening speed independent of the operator, the fuse isolator is provided with follow-up spring-loaded blade contacts similar to those on

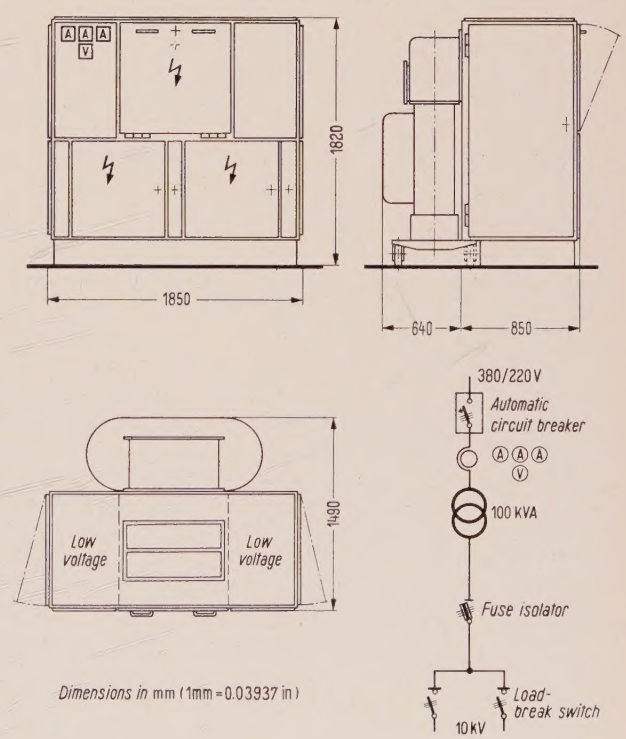


Fig. 2 Schematic representation of a 100-kVA load-centre unit substation, insulation rating 10 kV, for indoor installation and connection to ring mains

load-break switches. Switching under load is prevented by a mechanical interlock with the low-voltage automatic circuit breaker.

If in exceptional cases metering is required on the high-voltage side, the associated instrument transformers can be accommodated in the equipment cubicle.

On account of the relatively low transformer rating and the different nature of the load system, less equipment is required on the low-voltage side compared with larger stations. Generally an automatic circuit breaker suffices, to which may be added ammeters, voltmeters or a kWh meter.

In the design of these small transformer stations special emphasis has been laid on keeping the dimensions to a minimum so that they can also be installed in locations where space is restricted. In some cases the openings in the buildings in which the station is to be installed do not permit it to be transported as a whole. The transformer and the equipment cubicle are then delivered to the site separately, bolted together and provided with the associated connecting parts for the high and low-voltage side. In the case of stations for radial lines, the high-voltage sealing end can be accommodated completely inside the cubicle. For ring-main stations this is not possible and the foundation must also be used for this. The transformer stations can be installed indoors or outdoors. In the latter case the equipment cubicle is provided with a suitable cover and a special door behind which is arranged a protective cover against rain for raising when the door is open.

The relatively low weight, the small dimensions, the selected construction, the alternative design for indoor or outdoor installation and the ease with which they can be transported to another site make these small load-centre unit substations ideal for a wide range of applications.

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